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REGULATIONS, PRACTICES AND PLANS FOR THE PREVENTION OF SPILLS OF OIL AND HAZARDOUS POLLUTING SUBSTANCES. VOLUME I

A. E. Wechsler, et al

Arthur D. Little, Incorporated
Cambridge, Massachusetts

October 1971

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REGULATIONS, PRACTICES AND PLANS FOR THE PREVENTION OF SPILLS OF OIL AND HAZARDOUS POLLUTING SUBSTANCES

VOLUME I

October 1971

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FOREWORD

The enactment of the Water Quality Improvement Act of 1970 provided the necessary legislative force required to set in motion a vehicle designed to eliminate accidental spills of oil and hazardous materials through prevention. This study was designed to provide a basic working knowledge and understanding of existing rules and regulations, design concepts and operating practices in spill prevention to satisfy basic requirements set forth in Section 11(j)(1)(C) and 12(G) of the Act.

The main elements of this study are intended to complement an earlier study entitled, "Spill Prevention Techniques for Hazardous Polluting Substances" under EPA Contract 14-12-927 and published by the Water Quality Office, February 1971. This related report, "Regulations, Practices and Plans for the Prevention of Spills of Oil and Hazardous Polluting Substances," Volumes I and II, represents the results of a three-phase study effort to: (1) review Federal, State, local, commercial and industrial rules, regulations, standards and recommended practices to prevent the spills of oil and hazardous polluting substances, (2) survey selected facilities and plants in the field to document the state of the art in spill prevention technology and critically evaluate the "cause and effect" relationship of spill prevention technology to rules, regulations, and standards, (3) prepare a program plan (prototype plan) that proposes a balanced Federal, State, local and industry spill prevention program. Volume I presents the results of Phases 1 and 2; Volume II gives a summary of the program and presents the program plan.

In addition, this study shows that spill prevention for oil and hazardous polluting substances is practiced mainly as a result of fire and safety codes. There are, in fact, very few spill prevention programs for environmental protection at the Federal, State and local levels of government. The data documented in this study and the prototype plan could be used as a basis for identifying problems associated with spill prevention.

It is hoped that this will provide the necessary direction and guidance for all levels of government and industry to proceed with the development and implementation of a balanced spill prevention program.

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I. SUMMARY

PURPOSE AND SCOPE

The purpose of this program was to assess the state of the art of technology for the prevention, detection and control of spills of oil and other hazardous materials. More specifically, the goals were to:

- review and analyze "fail-safe" practices--regulations, design concepts and criteria, equipment and operational procedures used to prevent, detect or control spills or leaks of oil and hazardous materials;
- determine the level of utilization of these practices in industrial facilities and distribution systems;
- prepare a prototype plan for use in developing federal, state and local regulations, policies and programs pertaining to the prevention, detection and control of spills of oil and hazardous materials.

We focused attention on prevention of accidental spills because prevention is the first line of defense against environmental damage and strongly influences the requirements for detection and control. Emphasis was placed on methods for preventing spills of oil, other hydrocarbons and hazardous chemicals at refineries, terminals, storage, distribution, petrochemical, rubber, plastics, chemical and metal products facilities. Prevention, detection and control practices in off-shore and on-shore oil production were given only limited study because of their rather specialized technology.

APPROACH

To accomplish the program objectives, we undertook three tasks: (1) a literature survey, (2) a field survey of industrial facilities combined with discussions with industrial environmental managers and staff members of federal, state, and local regulatory agencies as well as designers/architects/engineers of industrial facilities, and (3) an analysis of the information gained and synthesis of a prototype plan.

We reviewed the laws, regulations and operating orders of federal agencies, such as the Environmental Protection Agency, Department of Transportation, Department of Interior, Corps of Engineers; the environmental and health agencies of about 40 states; and several metropolitan districts. We reviewed the recent technical literature, concentrating on those journals which represent the petroleum and chemical industries and environmental and waste treatment technologies. We reviewed the publications of trade, safety, fire protection and insurance associations, and examined industry and government agency reports of spills. We also examined a cross section of manufacturers' literature on spill prevention, detection and control.

Our field surveys were conducted in four geographic locations: Houston, Texas; California; the New York-New Jersey metropolitan area; and the Illinois-Michigan area. We visited 23 operating facilities representing petroleum refineries, bulk storage and distribution, petrochemical, chemical, synthetic rubber, plastics and metal products industries to determine the level of spill prevention currently practiced. Many of those facilities combined refineries, terminals, or several types of chemical processing and materials handling methods. We discussed the present use of prevention, detection and control techniques, procedures and equipment with plant managers and pollution control staff, and requested information on future needs of industry. We discussed regulatory practice and the state of the art of prevention during visits with eight state, federal and/or local regulatory agencies. We visited five architect-engineering firms responsible for the design and construction of new industrial facilities to determine the spill prevention measures which they presently incorporate in new facilities.

We examined and analyzed the information derived from the literature and field visits, and summarized the prevention technology applicable to five major "unit operations" encountered in industrial facilities--storage, transport, loading and unloading, processing, and waste treatment of oil and hazardous polluting materials. We compared our results with previous surveys at different locations. From this state-of-the-art summary, we developed a prototype plan which considers possible spill prevention regulations, penalties and incentives; development of an integrated prevention program; educational programs; and future equipment needs for prevention, detection and control.

RESULTS AND CONCLUSIONS

Regulatory Literature

- Present federal regulations are directed at establishing water quality and prohibiting spills of oil into the public waterways;
- The federal government has the mandate to study, encourage, and establish methods for prevention of spills, but, with a few exceptions, existing regulations provide little guidance or detailed information on prevention practices.
- The prevention of spills during offshore oil production is specifically addressed by the Department of Interior, U.S. Geological Survey Operating Orders in which detailed prevention practices are described.

- The water quality regulations of the states vary considerably in scope and content: emphasis is placed on water quality standards and municipal treatment programs, not on industrial waste treatment.

A majority of the states have regulations which provide for issuing permits, determining compliance and revoking permits for both municipal and industrial waste treatment facilities; one third of the states have specific regulations pertaining to prevention spills of oil; less than half of these also address spills of hazardous polluting materials.

- The major oil production states have specific regulations concerning the prevention of oil spills during production and transport to processing facilities.
- Several states have recognized the potential for pollution by oil and hazardous materials during transport and at terminal operations and have provided guidelines or detailed specific spill prevention procedures.

Trade and Technical Literature

- The principal causes of spills of oil and hazardous materials during fluid handling are human error, operational failures and equipment failures.
- Most of the technical literature on spill prevention is directed at the prevention of hazards to personnel and property by fire, explosion and toxic effects--protection of the environment is discussed infrequently.
- Industrial codes and standards adequately address problems of fire and design of equipment against mechanical failures; spill prevention is not specifically addressed, but most of the practices described in these codes and standards are valuable adjuncts to spill prevention.
- Although complete descriptive literature data on "fail-safe" equipment for spill prevention and instrumentation for spill detection is sparse, the trade literature of manufacturers indicate that an adequate number of devices are commercially available.

Field Survey

General Observations

- The most sophisticated prevention, detection and control technology is applied to those substances most hazardous to people, most damaging to property, or of high commercial value.
- The best developed containment, monitoring and treatment facilities are usually installed at facilities where the consequence of uncontrolled spills and leaks would be immediately evident through such visual indicators as floating substances, massive

fish kills, etc. The major attention has been given to oil, because it is the largest volume handled in commerce and is easily detected when spilled.

- Highly automated processing plants may have a significant potential for spills or leaks of hazardous polluting substances because the reduced number of operating personnel does not permit visual observations throughout the facility and because even the most sophisticated control systems are incapable of detecting small leaks and spills which can be extremely hazardous if allowed to enter the water.
- Very little instrumentation is installed solely for the detection of spilled substances; process instrumentation used in the transfer, storage and processing of hazardous polluting substances is applicable to detecting large spills but of doubtful value in detecting spills such as from small leaks.
- Catastrophic occurrences with a high potential for large volume spills, such as a tank rupture, receive the most public attention and consequently greatest consideration of prevention; chronic leaks and small spills which enter water probably have a greater accumulative effect but are given less attention at facilities.
- Separating areas of high spill potential and using collecting sewers and ditches that lead to containment areas where spilled substances can be monitored, treated and recovered is the most effective means of preventing hazardous polluting substances from entering water courses.
- Passive barriers for preventing the flow of spilled liquids are a highly desirable method of containment; however, containment dikes surrounding liquid storage tanks can often be breached or overflowed when a catastrophic failure occurs.
- Little consideration has been given to the possibility of ground water pollution as the result of leaks and spills; however, designs of modern facilities are giving this more consideration.
- Wide variations exist in the maintenance, housekeeping and operational practices of facilities handling similar types and volumes of hazardous polluting substances; therefore there is a broad range of spill incidences and prevention measures.

Causes of Spills

- Facility operators consider poor housekeeping practices and failure of operating personnel to perform their assigned jobs to be the principal causes of spills.
- Although equipment failures are known and documented causes of spills, they are probably less significant and more easily corrected and prevented than failures of operating personnel to perform satisfactorily.

- The potential for spills of hazardous polluting substances increases when facilities are being renovated or when repairs are being made.
- Loading and unloading operations have the highest spill potential because of the temporary nature of the connections between transport vehicles and transfer equipment and the large volumes of fluids transferred. The weakest points in transfer systems (pipelines) are at connectors, flanges, joints, valves, pumps and instrumentation inlets.
- Operating personnel generally have little awareness of the potential hazardousness of many substances when introduced into the water environment. Little attention has been given to the role of some actions, such as fire fighting in transporting spilled substances into water courses.

Specific Prevention Practices Used

The following specific prevention, detection, and control practices were observed most often in this field survey.

Practice	Area	Observed at % of Facilities
Dikes, fire walls or barriers around tanks	Storage	91
Monitoring of waste system effluent to aid in spill detection	Waste treatment	52
Hard surfaces or surfaces sloped and graded toward ditches or drainage system	Process	52
	Loading and unloading	30
	Storage	30
Curbing, gutters or drainage ditches around tanks or areas	Loading and unloading	48
	Process	48
	Storage	30
Separate process and storm water sewers	Waste treatment	48
	Process	30
	Storage	26
Holding or diversion ponds or lagoons	Waste treatment	43
Specific procedure for diverting or treating initial rainfall	Waste treatment	35
Periodic inspection of all pipelines for leaks, combined with preventive maintenance	Transfer	35
All pipelines located above grade to facilitate inspection	Transfer	35
Collection sumps and oil separators at each area	Loading and unloading	35
	Process	26
Manual gauging of tanks at regular intervals	Storage	30
Swivel joint loading arms or rigid connectors	Loading and unloading	30

Several of the facilities visited have established management practices to aid spill prevention. These included: employee motivation programs, placing responsibility for spills on individual operators, pollution control education programs, spill emergency reporting and specific training programs emphasizing pollution control.

In comparing the results of the present survey to similar surveys at other locations, we found the following prevention practices most commonly used:

Practices (Number of Facilities)	% UTILIZATION OF PREVENTION PRACTICES This Survey (23)	Composite Survey Chemical Facilities (31)	Composite Survey Total Facilities (107)
Complete Diked Storage	52	42	44
Tank Level Alarms	9	16	8
Above Ground Transfer Lines	35	23	11
Curbed Process Areas	48	52	22
Process Area Catch Basins	26	16	13
Holding Lagoons	43	42	17
Primary Waste Treatment	52	55	31
Secondary Waste Treatment	9	16	6
Spill Cleanup Equipment	13	3	16
Preventive Maintenance Program	35	33	18
Spill Control Plan	60	61	39

Prototype Plan

The prototype plan (Volume II) consists of a series of recommended actions to raise the level of spill prevention throughout government and industry. Some of the most important recommendations are:

- Oil and hazardous polluting substances should be placed on the same federal regulatory basis in terms of spill definition, prohibiting spills, spill prevention measures, penalties and incentives.
- States should be encouraged to evaluate, standardize and expand their regulations and procedures for prevention of oil spills as well as other hazardous materials to be commensurate with federal regulations.
- Facility operators should be required, as part of their waste discharge permit applications, to submit plans for preventing and controlling spills in accordance with federal and state regulations.
- Existing codes and regulations covering fire protection, pressure vessels, and pipelines should be expanded to include provisions for the prevention of spills of oil and hazardous materials.

Fire, safety, building, and air pollution regulatory groups should be encouraged to assist in water pollution prevention.

- An educational program on spill prevention, detection and control using several levels of communication media should be instituted by government and industry--specific emphasis should be placed on the individual's contributions to prevention, and in placing environmental protection at the same level as safety.
- Government and industry should cooperatively conduct demonstrations of integrated spill prevention programs designed to develop the required methodology and data and to show how best to implement spill prevention. These programs should include: assessment of hazards; establishment of short and long range levels of spill prevention; evaluation of existing prevention, detection and control technology; development and implementation of additional required prevention measures; establishment of a continuous program of quality control for spill prevention; documentation and evaluation of the effectiveness of the program.

II. INTRODUCTION

A. BACKGROUND

During the past several years, concern over water quality has been strongly aroused by major pollution incidents and by a growing awareness of the insidious environmental effects of the smaller leaks and spills of oil and other hazardous materials that occur daily on the land and in the water.

In response to this concern, government, industry and public groups have proposed and conducted a number of programs aimed at controlling spills of hazardous materials and at cleanup or recovery procedures. The Environmental Protection Agency, the U. S. Coast Guard and some state agencies are conducting broad programs to develop methods and equipment that will eliminate or confine hazardous materials should these be released into the water. The petroleum companies, both individually and collectively, are developing methods of cleaning oil from the water. Other industrial organizations have sought means to identify spills, control them, and clean them up. Public interest groups have contributed through their exposition of environmental damage and their attempts to assure passage of pollution control legislation.

Unfortunately, few of these efforts have been directed at the most promising solution to the problem--stopping pollution at the source through adequate spill prevention measures. Prevention makes both economic and environmental sense. Cleaning up the pollutant during the Santa Barbara incident, for example, may have cost as much as $5 million. In the recent Shell fire, pollution and well damage reportedly added up to more than $15 million. Of course, prevention of pollution equates to prevention of environmental damage.

If we are to develop an effective means of preventing spills of oil or other hazardous material, we need first to understand the nature and causes of such spills. Why do they occur? Where? What kinds? How big? Some of this information is already at hand; for example, a review of both state and federal reports suggests there are four major causes of spills: (1) human error, generally considered the greatest single cause of pollution incidents; (2) inadequate operational procedures or handling of hazardous materials; (3) poorly designed, inadequate, nonexistent, or faulty equipment; and (4) acts of nature. Data on other aspects of spill causes and nature have been reported by Battelle Memorial Institute[1], Arthur D. Little, Inc.[2] and Dillingham.[3]

Much data remain to be gathered or developed. Once these data have been translated into methods and equipment, the equipment must be installed and the methods must be applied. Systems must be human engineered to make them easy to operate. An on-going educational process must be

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instituted to make sure operators know how and why to use equipment properly. A system of checks must be maintained to monitor operational procedures. Regulations and construction codes must be drawn up and enforced. A device will not be useful unless it is used; an alarm will not be effective unless it is heeded.

B. THE SPILL PREVENTION PROBLEM

Spill prevention is primarily a materials handling problem of storing, transferring, or processing liquids. Even when the potentially hazardous substance is a solid it must often be handled in solution form or brought into solution through contact with the water environment.

Although the greatest number of widely publicized spills have occurred in the transportation phase of the petroleum industry, we have addressed problems of spills of hazardous polluting substances as well as oil at industrial sites for several reasons:

1. Spills of hazardous substances have been given much less attention than spills of petroleum products, probably because of their lower visibility and volume.
2. The spill potentials and problems of the transportation industry have been approached in detail through the development of codes and regulations, especially from the view of personnel and property hazards.
3. Industrial facilities are less uniformly regulated than transportation; a greater diversity of practices and systems are needed for the prevention, detection and control of spills.

In industrial operations handling or processing liquids which become hazardous polluting substances upon entry into the water environment, a number of practices and systems are found for the prevention, detection and control of spills or leaks. Many of these were installed for reasons other than environmental pollution--e.g.

- Personnel protection
- Property protection
- Compliance with fire and safety codes
- Preventing product loss because of its dollar value

Furthermore, each industrial facility, by virtue of its geographical, topographical and climatological characteristics will have some unique facets which will lead to unique spill prevention techniques not applicable at similar plants at different locations. The process industries have developed spill prevention techniques with varying degrees of sophistication, depending upon the specific materials handled, plant locations, and process requirements. Nevertheless, any useful application of technology to prevent, detect, and control spills must be based on broad principles of equipment design and operating procedures and practices.

1. Spill Areas

The handling and processing of liquids are difficult to categorize precisely for the purposes of establishing designs and developing procedures for preventing or controlling spills. However, we believe that four main areas of plant operations can be considered:

- Storage
- Transfer
- Loading and unloading
- Processing

These are characterized in this report as follows:

The Storage area is, virtually without exception, where the greatest volumetric containment of liquid occurs. It is the area which performs the prime function of providing for the reoccurring high volume movement of liquids between plant and transport, as contrasted to continuous and comparatively low volume flow of liquid to and from processing areas. In the storage area, spills are more frequently of large volume due to operational inattention or catastrophic failure and, as a consequence, are more damaging upon entry into water courses.

The Transfer area of a liquid handling facility comprises pipelines and the associated pumps, valves, and controls required in the transfer function. Spills are almost always the result of equipment failures in unattended areas. In this report, we refer to transfer area as pipelines or conduits through which liquids flow. Making connections with and discharging into tanks and permanent or temporary storage facilities is considered to occur in the loading and unloading area.

The Loading and Unloading area may be thought of as the interface through which incoming raw materials and outgoing products pass. This area is often the terminus of transfer pipelines which connect to raw material and product storage tanks. As a consequence, large volumes of liquids must be routed and the many temporary connections required in the operation is a major problem.

A Processing area consists of equipment and facilities in which raw materials are converted into products. In this area the major spill problems are associated with the innumerable pumps, valves, instruments and equipment failures associated with the physical and chemical changes being carried out.

Another area for spills is the waste treatment area. However, a waste treatment facility is often a means for preventing spills in other locations from reaching the water resources.

2. Spill Potentials

The potential and magnitude of spills and leaks from the major areas discussed above is dependent upon a number of variables and these cannot be generalized easily. However, there appear to be five major factors contributing to the quantitative description of spill potential. (See Table 1.) First is the inventory volume of liquid since the larger the volume, the greater the potential hazards to a water environment from a spill. A very low spill potential exists because of inventory effects in a loading and unloading area while a very high potential exists in the storage area.

The second descriptor of spill potential is the frequency of operating cycles. Significantly greater potential exists at the beginning and ending of operational cycles due to a variety of reasons including mechanical ones such as the danger of loose connections, and operational ones such as unsteady state conditions. A third descriptor of great importance in loading and unloading areas is the high ratio of temporary to permanent connections. Each time a pipeline is connected or disconnected, the potential exists for improper pipe fit, and for damage and wear to the pipe connectors. In contrast, since a permanent connection is made only once and often hydraulically tested before use, the low ratio of temporary to permanent connectors gives the transfer area of a plant a low potential for spills.

The volumetric rate at which liquids are moved to and from storage and processing areas can cause a high spill potential to exist, e.g., in the unloading of supertankers where transfer rates of 10,000 to 20,000 tons per hour may occur. Obviously, a pipeline break which is not quickly detected can result in spilling large volumes of liquids. The ubiquitous human factor in spills must be considered a very important descriptor of spill potentials. The greater dependence upon the human factor in general, the higher the spill potential. An overall ranking of the spill potential of the four areas suggests that loading and unloading and storage areas represent the highest spill potential, followed by processing and transfer operations.

C. APPROACH

Our investigation consisted of three parts--survey and analysis of the regulatory, trade, and technical literature; field survey and evaluation of the state of the art of spill prevention, detection and control technology; and analysis and development of a prototype plan describing future courses of action for the Environmental Protection

TABLE 1

MATRIX FOR CONTRASTING AND RANKING THE MAIN FUNCTIONS OR AREAS IN LIQUID HANDLING FACILITIES

	Storage	Transfer	Loading & Unloading	Processing
Inventory of Contained Liquid	Very High	Low	Very Low	Low
Frequency of Operating Cycles	Low	Moderate	Very High	Moderate
Ratio: $\frac{\text{Temporary Connections}}{\text{Permanent Connections}}$	Very Low	Very Low	Very High	Moderate
Dependence Upon Human Factor	High	Low	Very High	High
Volumetric Transfer Rate	Low	High	High	Variable
Overall Spill Potential	High	Moderate	High	Moderate

Agency to further the "spill prevention" concept. We focused on accidental spills and leaks of oil and other hazardous materials from large and small industrial facilities. Only modest attention was paid to offshore and onshore petroleum production because these areas are so large and complex, and have a separate technology base, that they are beyond the scope of our present work.

We examined federal regulatory literature and the rules and orders of agencies such as the Environmental Protection Agency, U. S. Coast Guard, U. S. Geological Survey, Maritime Administration, and the Corps of Engineers. Letters were written to over 30 state pollution control and health agencies requesting information on rules, regulations and orders pertaining to prevention of spills of oil and other hazardous materials. Fire marshalls of several states and municipalities were contacted. We reviewed the existing regulations to determine which provisions addressed spill prevention--design criteria, "fail-safe" equipment, and procedures. This survey was complemented by personal visits and telephone contact with several state agencies.

We briefly examined the causes of spills reported in the literature, the corrective actions taken, and preventive measures which might eliminate these potential hazards in other facilities. Our attention was focused on chronic spills of oil and hazardous materials at industrial facilities because many reviews presented at oil pollution control conferences and reports in the open literature have discussed the major oil spills.[4] [5]

Our review of the technical and trade literature was limited to the last several years' publications. We examined publications of trade associations such as the American Petroleum Institute and Manufacturing Chemists Association; trade and technical journals such as the Oil and Gas Journal, Journal of Waste Water Treatment, and Chemical Engineering; and abstract indices such as Chemical Abstracts and Index to Government Reports. Although much literature was available from manufacturers, most of it described oil detectors, valves, level indicators, alarms, etc. We did not feel that an extensive review of such equipment was warranted--more important is the general knowledge that these devices are available on the open market.

In our field survey, we visited 23 large and small facilities in the petroleum refining, oil storage and distribution, petrochemical, organic and inorganic chemical, plastics and rubber, and metal products industries.(See Table 14.) The survey was conducted in four locations--Houston, Texas; Los Angeles and San Francisco, California; the New York-New Jersey area; and the Illinois-Michigan area--representative of the variety of geographical, climatological, and industrial ranges encountered in the United States. Visits to these facilities were arranged through the Regional Offices of the Environmental Protection Agency, State Pollution Control Agencies, and our own personal contacts in industry.

The objective of these visits was to obtain information about the level of spill prevention technology actually practiced in industrial facilities and information about how spill prevention techniques might be improved or further developed. Information exchange was facilitated by our agreement with industrial representatives not to "single out" by name specific organizations with limited or inadequate prevention programs, nor to disclose past problems with spills or present hazards, but to focus on existing prevention techniques and how industry and government can cooperate to improve the present situation.

Field surveys at working facilities were supplemented by visits to five architect-engineering firms active in the design, development and construction of industrial facilities. (See Table 14.) These discussions helped to identify the types of design criteria and equipment for spill prevention that are used in new plant construction. We also visited with several state and municipal water pollution control agencies to determine their view of present pollution prevention practices. The information gained from these visits was reviewed and summarized in terms of the design criteria, equipment, operational procedures, and practices used to prevent spills in the storage, transfer, loading and unloading, processing, and waste treatment of oil and hazardous materials.

The last part of our program was the preparation of a prototype plan for Environmental Protection Agency action. Several approaches were considered--development and promulgation of new rules and regulations, methods for determining the hazards and spill prevention requirements of specific industries; educational programs for industry management and operational personnel; spill prevention demonstration programs; and determination and development of additional equipment required for spill prevention. It was clear from our visits to industrial facilities that a broad range of spill prevention technologies is being practiced depending upon the type, size, age, and location of the facility as well as the materials handled. Thus, we had to consider programs which are sufficiently flexible to be feasible within the diverse industrial spectrum, yet lead to a more uniform and effective spill prevention practice.

Regulations must be enforceable, procedures must be adaptable to specific industries, equipment must be usable in both old and new facilities. Thus, our efforts were directed to development of a plan which is guided and enforced by government, implemented and accepted by industry, and provides the necessary spill prevention for environmental protection. The prototype plan is given in Volume II of this report.

III. LAWS AND REGULATIONS FOR SPILL PREVENTION

One objective of this program was to review the status of laws, rules, and regulations pertaining to the prevention and control of spills of oil and hazardous polluting substances. Because of the multi-agency jurisdiction over spills of oil and hazardous materials, we examined laws and regulations of federal, regional, state, and municipal water quality and health agencies. We requested information on pertinent laws, regulations and orders from 30 state water pollution regulatory agencies, 20 individual environmental engineers at state agencies, 17 state or city fire marshalls, 6 intergovernmental groups and 23 industry associations. (See listing given in Appendix A.) We also reviewed pertinent regulations of the United States Geological Survey for offshore petroleum wells, the Hazardous Materials Regulation Board of the Department of Transportation Bureau of Land Management, rules of regulatory agencies in oil producing states, and fire and insurance underwriter codes.

This review established that: (1) most laws and regulations are directed toward the protection of personnel and property from the consequences of spills of oil and hazardous substances, (2) the regulations for maintaining water quality consider detection, surveillance, and cleanup of spills once these have occurred, but rarely specify detailed prevention measures, (3) most regulations are concerned with oil spills; other hazardous materials are mentioned infrequently. These conclusions are amplified in the discussion on the following pages.

A. FEDERAL REGULATORY PRACTICE

1. Federal Water Pollution Control Act

The Federal Water Pollution Control Act clearly recognizes the requirements for prevention within the overall concept of water quality:[6]

> "Section. 1. (a) The purpose of this Act is to enhance the quality and value of our water resources and to establish a national policy for the prevention, control, and abatement of water pollution."
>
> "...it is hereby declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution..."
>
> "Sec. 4. (a) The Secretary shall encourage cooperative activities by the States for the prevention and control of water pollution..."

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These provisions both recognize the need for prevention and indicate that a joint federal-state effort is desirable and required for the prevention of pollution. The provisions listed below call for research investigation, training and dissemination of information on the subject of prevention of pollution:

> "...conduct in the Department of the Interior and encourage, cooperate with, and render assistance to other appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, control, and prevention of water pollution."
>
> "...provide training in technical matters relating to the causes, prevention, and control of water pollution to personnel of public agencies and other persons with suitable qualifications."
>
> "...collect and disseminate basic data on chemical, physical, and biological water quality and other information related to water pollution and the prevention and control thereof."
>
> "...enter into contracts with, or make grants to, public or private agencies and organizations and individuals for (A) the purpose of developing and demonstrating new or improved methods for the prevention, removal, and control of natural or man made pollution in lakes..."

Note that training is recognized as an important aspect of water pollution control. As demonstrated elsewhere in this report, many pollution incidents are the results of human error. Some of these could be eliminated through training programs, either industry or government sponsored, that point up the importance of each individual in the total prevention program.

The Act clearly indicates that discharges of oil should be prevented.

> "...the Congress hereby declares that it is the policy of the United States that there should be no discharge of oil into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone."

The Act continues to specify penalties for persons discharging oil, to provide for the National Contingency Plan, and contains provisions for cleanup and control of oil pollution. The requirements for new regulations on prevention are cited in Section 11 (j), as follows:

> "...Consistent with the National Contingency Plan..., the President shall issue regulations consistent with maritime safety and with marine and navigation laws..., (C) establishing procedures, methods, and requirements for equipment to prevent discharges of oil from vessels and from onshore facilities and offshore facilities..."

Section 12, which deals with control of hazardous polluting substances, provides for the designation of hazardous substances and methods for removal of these materials.

> "Sec. 12. (a) The President shall develop, promulgate, and revise as may be appropriate, regulations (1) designating as hazardous substances, other than oil as defined in Section II of this Act, such elements and compounds which, when discharged in any quantity into or upon the navigable waters of the United States or adjoining shorelines or the waters of the contiguous zone, present an imminent and substantial danger to the public health or welfare, including, but not limited to fish, shellfish, wildlife, shorelines, and beaches; and (2) establishing, if appropriate, recommended methods and means for the removal of such substances."

Under Section 12 the President is also to study methods and measures for controlling hazardous substances to prevent discharge. Under the provisions of the Federal Water Pollution Control Act, the designation of hazardous substances is proceeding.

2. Executive Order 11507

Under Executive Order 11507,[7] the federal government is charged--in the design, operation and maintenance of its facilities--with providing leadership in the nationwide effort to protect and enhance the quality of our air and water resources. Two parts of this Executive Order are important statements relating to the prevention of pollution by oil and hazardous materials:

> "...Heads of agencies shall ensure that all facilities under their jurisdiction are designed, operated, and maintained so as to meet the following requirements: (2) Actions shall be taken to avoid or minimize wastes created through the complete cycle of operations of each facility."

> "(4) The use, storage, and handling of all materials, including but not limited to, solid fuels, ashes, petroleum products, and other chemical and biological agents, shall be carried out so as to avoid or minimize the possibilities for water and air pollution. When appropriate, preventive measures shall be taken to entrap spillage or discharge or otherwise to prevent accidental pollution."

These can be interpreted as calling for an evaluation of operations (i.e., processes, procedures, equipment, etc.) at each facility to avoid or minimize waste and thereby minimize the waste pollution problem. They also imply a "fail-safe" concept, i.e., preventive measures to entrap spillage or discharge or otherwise prevent accidental pollution. These two sections, if expanded and applied to industrial facilities, would be a major force in preventing pollution by oil and hazardous materials.

3. United States Department of the Interior

Some of the most specific regulations for preventing pollution from accidents have been promulgated by the Department of the Interior's U. S. Geological Survey in regulations concerning the conduct of mineral operations and developments in the Outer Continental Shelf (30 CFR Part 250).[8,9] In addition, these regulations are made a part of the leasing program administered by the Bureau of Land Management as outlined in 43 CFR, Part 3380.[10] The outer Continental Shelf Orders have been issued by the Gulf Coast and Pacific regions of the Branch of Oil and Gas Operations, Conservation Division of the U. S. Geological Survey. The intent of these orders in each region is similar; however, the specific conditions and language employed varies. Although these orders are specifically addressed to oil, gas and sulfur producing wells on the Outer Continental Shelf, we found these to contain more specific conditions and procedures useful in preventing and controlling spills than in any other federal regulations and have recorded in the following Table 2 the ones we judge as most pertinent.

4. Department of Transportation

The Hazardous Material Regulation Board of the Department of Transportation has established safety regulations for the design, construction, operation, and maintenance of pipelines carrying hazardous materials and petroleum products in liquid form. These regulations are issued as 49 CRF, Part 195--Transportation of Liquids by Pipelines. These regulations fall into the following categories:

- Sub Part A - General
- Sub Part B - Accident Reporting
- Sub Part C - Design Requirements
- Sub Part D - Construction
- Sub Part F - Operational Maintenance

TABLE 2

UNITED STATES GEOLOGICAL SURVEY -OUTER CONTINENTAL SHELF REGULATIONS

	UNITED STATES GEOLOGICAL SURVEY	
Items	Gulf Coast Region	Pacific Region
1. Well Casing and Cementing		
A. Drive or Structural Casing	OCS No.2—Item 1A	OCS No.10--Item 1A1
B. Conductor and Surface Casing	OCS No.2—Item 1B	OCS No.10--Item 1A2
Specific Depths	OCS No.2--Item 1B	OCS No.10--Item 1A2-ii
C. Intermediate Casing	OCS No.2--Item 1C	OCS No.10--Item 1A4
D. Production Casing	OCS No.2--Item 1D	OCS No.10--Item 1A5
E. Pressure Testing	OCS No.2—Item 1E	OCS No.10--Item 1A6
2. Blowout Prevention		
A. Equipment	OCS No.2--Item 2	OCS No.10--Item 1B1
B. Mud Program	OCS No.2--Item 3	OCS No.10--Item 1C
3. Plugging and Abandonment of Wells	OCS No.3	OCS No.3
4. Storm Choke or Similar Subsurface Safety Device	OCS No.5	OCS No.10--Item 2
5. Procedure for Completion of Oil & Gas Wells	OCS No.6	OCS No.6
6. Pollution and Waste Disposal		
A. No Oil into Water	OCS No.7--Item 1A1	OCS No.7
B. No Harmful Liquid Waste into Water	OCS No.7--Item 1A2	OCS No.7
C. All Pollution Control Equipment Must Be Maintained	OCS No.7—Item 1C1	
D. All Platforms & Structures, Curbed and Drained to Tank or Sump	OCS No.7--Item 1C2	OCS No.10--Item 5-7
E. Operating Personnel Thoroughly Trained	OCS No.7--Item 1C3	
F. Pollution Inspections (Manned-Daily, unattended-frequently)	OCS No.7--Item 2A	
G. Reporting of Spills and Leaks	OCS No.7--Item 2B	
H. Spill Emergency Plan—Corrective Action	OCS No.7--Item 3A1	
I. Spill Control Equipment		
1. Booms	OCS No.7--Item 3B	OCS No.10--Item 6
2. Skimming Apparatus	OCS No.7--Item 3B	OCS No.10--Item 6
3. Approved Dispersants	OCS No.7--Item 3B	OCS No.10--Item 6
7. Production Platform Requirements		
A. Gas Detector and Alarm System	OCS No.8--Item 2A7	OCS No.10--Item 5-1
B. Approved Fire Fighting System	OCS No.8--Item 2A6	OCS No.10--Item 5-2
C. High and Low Level or Pressure Alarms and Shutdown Devices in all Production Vessels and Water Separation Devices	OCS NO.8--Item 2A1	OCS No.10--Item 5-3
D. Remote and Local Automatic Platform and Well Shutdown Devices	OCS No.8--Item 2A2	OCS No.10--Item 5-4
E. High & Low Pressure Oil Pipeline Alarms & Control Devices to Shutdown Shipping Pumps & to Shut in all Well in Event of Actuation	OCS No.9--Item 1A1	OCS No.10--Item 5-5
F. Approved Sewage Disposal System	OCS No.8--Item 2A9	OCS No.10--Item 5-6
G. Auxiliary Power Supply Equipment	OCS No.8--Item 2A4	OCS No.10--Item 5-8
H. Approved Waste Water Handling and Disposal System	OCS No.8--Item 2A5	OCS No.10--Item 5-9
8. Gathering Pipelines		
A. Automatically Controlled Shutoff Valves	OCS No.8--Item 2A2	OCS No.10--Item 3-1
B. Corrosion Protection		OCS No.10--Item 3-2
C. Check Valves	OCS No.8--Item 2A2	OCS No.10--Item 3-3
D. Other Spill Preventing Equipment		OCS No.10--Item 3-4

While these regulations include many standards which are principally responsible for insuring that adequate safety precautions are realized in design, construction, operation and maintenance of pipelines, the only portion directly pertinent to pollution control is the requirement of telephonic notice of leaks at the earliest practicable moment following discovery that resulted in pollution of any stream, lake, river, or other similar body of water.

B. STATE AND REGIONAL REGULATORY LITERATURE

Within the scope of the present study it was not possible to investigate the latest regulatory literature of all states in great detail. As a preliminary exercise, we reviewed the State Water Quality Laws, as compiled in the Environment Reporter issued by the Bureau of National Affairs, Inc., to determine which state agencies have specific authority to regulate spill prevention techniques. The types of regulations and the fraction of states which have regulations are shown below:

	Types of State Regulations	% of States with these Regulations
1.	Develop programs for treatment and disposal	48
2.	Establish Water Quality Standards	60
3.	Examine plans and give approvals for wastewater treatment	64
4.	Issue permits, determine compliance, and revoke permits	92
5.	Adopt rules and regulations to abate and prevent pollution	68

The pertinent information for each state is given in Table 3. Although over 2/3 of the states have regulations which cover pollution abatement, only a few have specific regulations pertaining to spills of oil and hazardous materials. Table 4 indicates those states for which specific spill regulations were found as the result of direct inquiries (see Appendix A for list of contacts and responses) or from information received during field interviews. From this review, we conclude that pollution by discharge of oil or petroleum products is addressed in greater depth and more frequently than pollution by hazardous materials. While major oil producing states have specific regulations concerning production of oil and the prevention of oil pollution during production, a limited number of states have recognized the potential for pollution

TYPES OF STATE WATER POLLUTION REGULATIONS

	Develop Programs for Treatment and Disposal	Establish Water Quality Standards	Examine Plans and Approve Wastewater Treatment Plans	Issue Permits Determine Compliance, Revoke Permits	Adopt Rules & Regulations to Abate & Prevent Pollution
Alabama	X	X	X	X	
Alaska		X		X	X
Arizona			X	X	X
Arkansas	X	X		X	X
California	X	X			X
Colorado	X			X	X
Connecticut	X	X	X	X	
Delaware	X			X	X
Florida	X	X		X	X
Georgia	X	X		X	X
Hawaii				X	X
Idaho		X	X		X
Illinois				X	
Indiana		X		X	X
Iowa		X	X	X	
Kansas		X		X	
Kentucky	X	X	X	X	X
Louisiana		X		X	X
Maine			X	X	
Maryland					X
Massachusetts	X		X	X	
Michigan		X		X	X
Minnesota		X	X	X	
Mississippi	X			X	X
Missouri			X	X	X
Montana	X	X		X	X
Nebraska	X		X	X	X
Nevada				X	X
New Hampshire	X		X	X	X
New Jersey		X	X	X	X
New York			X	X	X
New Mexico		X	X	X	X
North Carolina	X	X	X	X	X
North Dakota	X		X	X	X
Ohio	X		X	X	
Oklahoma	X	X	X	X	X
Oregon	X	X	X	X	X
Pennsylvania			X	X	X
Rhode Island	X	X	X	X	X
South Carolina		X		X	X
South Dakota		X	X	X	
Tennessee	X	X	X	X	
Texas	X	X	X	X	
Utah		X	X	X	
Vermont	X		X	X	X
Virginia		X	X	X	X
Washington			X	X	
West Virginia			X	X	
Wisconsin	X	X	X	X	
Wyoming		X	X		X

TABLE 4

SPECIFIC STATE SPILL PREVENTION, RULES, REGULATIONS AND LAWS

Spill Prevention Regulations

State	Oil	Other than Oil	National or Local Contingency Plan
Alaska	X	X	
California			X
Colorado	Reporting only		
Florida	(in Litigation)		
Louisiana	X		
Maine	X		
Maryland	In Preparation		
Massachusetts	Filed		
Michigan		Being Considered	X
Nebraska	X	X	X
New Jersey		X	Being Adopted
New York	X	X	
Pennsylvania		X	
Rhode Island	X		
Texas	X		
Wisconsin	X		Planned

by oil and hazardous materials during transport and at terminal operations by providing both guidelines and in some cases specific procedures to prevent pollution. The most pertinent and applicable state regulations for spill prevention, including those which provide for specific procedures, methods and equipment for preventing spills of oil and hazardous materials, are reviewed on the following pages.

1. Specific Preventive Measures

The regulations of several state agencies describe specific procedures, methods, and equipment to be used for preventing spills of oil and hazardous materials. Some of these are reviewed below.

The Rhode Island Department of Health[11] provides many specific regulations concerning procedures and equipment pertaining primarily to transfer of oil from a vessel to shore or from shore to vessel, and at storage and terminal operations. Some examples of the regulations are the pressure testing of flexible hoses used in transfer operations, the use of drip pans under hose connections, proper support for hoses and sufficient length to avoid any strain, illumination of wharves or pier areas during transfer operations, check valves in discharge lines, closing of valves in dike surrounding tanks, storage tank inlets, overflows and vents, etc. Because of the broad scope of these regulations, they have been reproduced in Appendix B.

Massachusetts' Division of Water Pollution Control[12] has filed rules pertaining to marine oil transfer operations, terminal and bulk plants and other oil handling installations, spills, and other accidental discharges. The marine oil transfer operation specifies procedures and equipment such as: plugging of scuppers, blanking ends of hoses, drip pans, checking connections, flanges and joints, curbs on wharves or piers, etc. Other parts of the regulations require dikes or retaining walls around tanks or tank batteries, use of oil traps in terminal areas, and granting of licenses to terminal operations. Parts of these regulations are included in Appendix C.

Alaska,[13] in its oil and gas conservation regulations and statutes, provides for prevention of leaks and breaks in wells and piping as well as other prevention measures. There is also a list of regulations pertaining to the prevention of industrial waste pollution. General guidelines are given for industries as varied as meat packing plants and canneries, metal industries, and pulp and paper mills. Most of these regulations are general but specific procedures for oil separation and collection are given. The broad potential of these regulations is illustrated by the section entitled "Oil Transportation Equipment."

> "...Tankers, railroad tank cars, tank trucks, or other facilities and for the loading, unloading, storage, and transportation of oil shall be equipped for the collection of the drips from hose or other connections and

> the excess oil contained in hose and pipelines, wherever there is a possibility that this oil will find its way, either directly or indirectly, into a body of water. Provision shall be made, also, for catching accidental spills, and these facilities shall be of such a capacity as to hold the maximum quantity of oil possible from any one spill."

The provision indicates that facilities should be available to hold the maximum quantity of oil that could be released in any spill; implementation of such regulation could prevent many accidental spills which might otherwise make their way to the water.

Louisiana's Stream Control Commission has rules governing disposal of waste oil, oil field brine, and all other materials resulting from the drilling for, production of, or transportation of oil, gas or sulphur.[14] The most pertinent of these from the viewpoint of spill prevention are as follows:

> "1. Crude oil, waste oil, oil sludge, oil-water emulsion, or oil bearing mixtures of any kind shall be gathered and destroyed by burning or otherwise on the lease where the wastes originate, and in such manner as to eliminate any pollution hazard.
>
> "2. No oily fluids shall be discharged to, or allowed to flow on the ground, or be carried from the original lease in open ditches, or discharged or allowed to flow into any stream, lake or other body of water."
>
> "3. a. Each producing well, except those over marsh and water, all oil booster pumps, and any pump used to move oil or oily fluids, shall be provided with a surrounding gathering ditch or equally effective device, to prevent the escape of oily wastes from the location, such ditch to be graded to a gathering sump which shall be cleaned regularly by removal and destruction of oily wastes. All spillage of oil shall be promptly gathered and destroyed.
>
> b. On all pumping wells, over water or marsh, there shall be installed an adequate impervious deck or other device with a catch tank installed around the wellhead. The catch tank should be equipped with a "stiff-leg" to enable the operator to dispose of excess rainfall.

c. All drilling barges, whether for workover or drilling new wells shall be equipped with a device at the open end or ends of keyways to prevent oil or oil fluids from escaping therefrom. This device shall be so installed as to be adjustable for tidal changes and all oil collected within keyways shall be picked up and disposed of in compliance with paragraphs 1 and 2."

"4. Each permanent oil tank or battery of tanks that are located within the corporate limits of any city, town, or village or where such tanks are closer than 500 feet to any highway or inhabited dwelling or closer than 1000 feet to any school or church, or where such tanks are so located as to be deemed a hazard by the Stream Control Commission, must be surrounded by a dike (or fire wall) or retaining wall of at least the capacity of such areas where such dikes (fire walls) or retaining walls would be impossible such as in water areas. At the discretion of the Stream Control Commission, fire wall of 100% capacity can be required where other conditions or circumstances warrant their construction. (As Amended December 13, 1964.) Tanks not falling in the above categories must be surrounded by a retaining wall, or must be suitably ditched to a collecting sump, each of sufficient capacity to contain the spillage and prevent pollution of the surrounding areas."

"5. Oil gathering lines, or any other lines used for transporting oil, shall be regularly inspected and all leaks shall be immediately repaired. Waste from leaks shall be collected and destroyed immediately upon discovery. All barges used for the transportation of crude oil or petroleum products shall be in first class condition. Leaking barges shall be repaired before reuse. Loading racks, barge-loading outlets, and similar installations shall be operated at all times with full precaution against spillage. Such installations shall be surrounded by a ditch graded to a gathering sump, or shall be provided with an impervious deck surrounded by a steel gutter leading to a sump, or with such other equipment adequate for the accomplishment of the same purpose as may be approved by the Stream Control Commission. All such gathering sumps shall be cleared regularly by removal and destruction or other safe disposal of the oily waste. After each operation of barge or tanker loading equipment, loading hose and connections shall be carefully drained, and the gathering sumps shall be emptied, preferably to the barge or tanker."

In Texas, Statutory Authorization, Article 7621d, Section 10(c)(4), places sole responsibility on the Railroad Commission of Texas for the control or disposition of waste, and abatement and procedures of pollution of water, both surface and sub-surface, resulting from activities associated with the exploration, development, or production of oil or gas. The commission issues its rules and regulations under the title "General Conservation Rules and Regulations of Statewide Application, State of Texas".[15] Many of these are similar to those of the USGS's Outer Continental Shelf Regulations. The directly applicable regulations are found in Rule 8, Water Protection given in Appendix D.

The following four state laws specifically apply to prevention of discharge of hazardous materials and other wastes and provide a mechanism for state regulation of prevention and control procedures.

> State of New York. Item 13, Section 10, Article 2 of Chapter 140 of the Laws of New York. "The Department of Environmental Conservation...shall have power to: 13, Prevent pollution through the regulation of the storage, handling, and transport of solids, liquids and gases which may cause or contribute to pollution."
>
> Commonwealth of Pennsylvania. Section 402, Potential Pollution, Article IV, Clean Stream Law as Amended, July 31, 1970.
>
> a. Whenever the board (Department of Environmental Resources) finds that any activity, not otherwise requiring a permit under this Act, including but not limited to the impounding, handling, storage, transportation, processing and disposing of materials or substances, creates a danger of pollution of the waters of the Commonwealth or that regulation of the activity is necessary to avoid such pollution, the Board may, by rule or regulation require that such activity shall be conducted only pursuant to a permit issued by the Department or may otherwise establish the conditions under which such activity shall be conducted, or the Board may issue an order to a person or municipality regarding the particular activity. Rules and regulations adopted by the Board pursuant to this section shall give the persons or municipalities affected a reasonable period of time to apply for and obtain any permits required by such regulations.
>
> Commonwealth of Virginia. Article 3--Regulation of Industrial Establishment, Section 62.1-44.16

1. Any owner who erects, constructs, opens, reopens, expands or employs new processes in or operates any establishment from which there is a potential or actual discharge of industrial wastes or other wastes to state waters shall first provide facilities approved by the Board for the treatment or control of such industrial wastes or other wastes.

62.1-44.17"...shall upon request of the Board install facilities approved by the Board or adopt such measures approved by the Board as are necessary to prevent the escape, flow or discharge into any State waters when the escape flow or discharge of such other wastes into any State waters would cause pollution of such State waters."

The State of Rhode Island in its pollution regulations provides a mechanism for adoption of pollution prevention procedures, following an incident in which pollution has occurred. This order reads as follows:

"...Order to adopt pollution prevention systems --If any person is polluting the waters of the state, and if after such investigation the director shall so find, he shall make his findings in writing to that effect and may enter an order directing such person to adopt or use or to operate properly, as the case may be, some practicable and reasonably available system or means to prevent such pollution, having due regard for the rights and interests of all persons concerned. Such order may specify the particular system or means to be adopted, used or operated; provided, however, that where there is more than one such practicable and reasonably available system or means, such order shall give to the person complained of the right to adopt or use such one of said systems or means as he may chose."

Other laws are less specific in that they prohibit pollution but do not provide for spill prevention control, for example:

State of Nebraska. 71-3007. Unlawful Acts

1. It shall be unlawful for any person:

a. To cause pollution of any waters of the state or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any water of the state...

State of New Jersey.

4. The discharge of hazardous substances, debris, and petroleum products into or in a manner which allows flow or runoff into or upon the waters of this State and the banks or shores of said waters is prohibited.

From this review of state water quality laws we conclude that specific legislation permitting regulatory bodies to establish rules and regulations directed at methods for preventing spills from occurring and from entering water courses is inadequate to insure that the handlers of hazardous polluting substances are taking actions necessary to prevent spills of hazardous substances from polluting the Nation's water resources.

C. FIRE LAWS AND FIRE PREVENTION AND UNDERWRITER CODES

The laws and regulations for fire protection are primarily for protection of people and property, especially in the handling of flammable liquids. Although the requirement of dikes around any tank storing flammable liquids is an excellent regulation from the viewpoint of preventing widespread pollution upon rupture of a tank, the reasons for this requirement are solely for protection of people and property. Consequently, fire laws and codes can be considered as valuable but specific adjucts to rules and regulations required to decrease the potential for spills of hazardous substances entering water courses; however, they are only that--valuable adjuncts.

IV. TECHNICAL AND TRADE LITERATURE

We surveyed recent technical and trade literature to determine (1) the recorded causes of spills of hazardous polluting substances, (2) equipment, design criteria and procedures for spill prevention and (3) indication of the extent to which techniques and equipment are used to prevent and control spills of hazardous materials. The results of this survey formed a basis for establishing the direction of the plant surveys in which we sought additional information for evaluating the practices of industry in preventing and controlling spills. Literature sources for this survey are listed in Table 5 and were limited primarily to publications of the last three years since previous work had indicated that prior to 1967, few articles had reported on spills of oil and hazardous materials. We specifically contacted 23 professional and trade associations to obtain their publications. (See Appendix A.)

A. CAUSES OF SPILLS

We concentrated on obtaining information on hazardous materials other than oil because the latter have been well documented and we were seeking information on much broader types of materials. Table 6 illustrates the types and causes of spills. The preventative actions that have been recommended by the investigating groups to eliminate subsequent failures are also listed in Table 6. These actions deal primarily with the correction of equipment failures; however, consideration of the nature of the failures suggests that more attention to inspection, maintenance and general good housekeeping could have prevented many of these accidental spills.

The failures recorded in Table 6 that resulted in accidental spills of chemicals are similar to those reported as causes of oil spills entering the River Thames outside of London.[19] Of 394 reported oil spills, 30% resulted from storage of oil, 10% from oil pipelining, 10% from the disposal of waste oil, 11% from engines, auto service stations vehicle depots, railroad and air fields, 5% from road tank-truck accidents, 23% from general spillage, and the remaining 11% being unknown. Of 90 small and large spills originated from oil storage installations, 35 were caused by overfilling of tanks and 51 by leaky valves or from valves that had been damaged deliberately. At least 74 of these incidents could have been avoided if elementary precautions had been taken in designing the tank storage area. Nearly all of the spills from oil tanks were attributable to human error. Pipeline failures were due to corrosion, a lack of cathodic protection, or by structural damage during road construction. Most of the spills in industrial facilities were caused by careless use of oil, spillage or improper disposal by employees.

TABLE 5

SOURCES USED IN LITERATURE SURVEY

Abstracting and Indexing Services

Engineering Index
Oceanic Index
Applied Science and Technology Index
U. S. Government Research and Development Reports Index
Technical Abstract Bulletin Index
Chemical Abstracts
Nuclear Science Abstracts
Air University Library Index to Military Periodicals
Department of Interior, Office of Water Resources Research, Water Resources Research Catalog

Federal Agencies

Government Printing Office Monthly Catalog: GPO Price Lists, #42, Irrigation, Drainage and Water Power, and #58, Mines, Explosives, Fuel, Gasoline, Gas, Petroleum, Minerals
Various Agencies and Departments: Department of the Interior (FWQA, USGS); Office of Water Resources Research; Department of Transportation (USCG); Department of Commerce (NOAA); AEC; Council on Environmental Quality, Environmental Protection Agency; National Science Foundation; Water Resources Council; National Council on Marine Resources and Engineering Development

Scientific and Technical Societies

American Petroleum Institute
American Chemical Society
American Institute of Chemical Engineers
American Institute of Mining, Metallurgical and Petroleum Engineers
American Nuclear Society
American Society for Metals
American Society of Civil Engineers
American Society for Testing and Materials
American Society of Mechanical Engineers
Compressed Gas Association
Manufacturing Chemists Association
National Academy of Sciences, National Academy of Engineering, National Research Council
American Insurance Association, Engineering and Safety Department

Selected Journals

Chemical Engineering
Chemical Engineering Practice
Oil and Gas Journal
Chemical Engineering Progress
Ocean Oil
Oil, Gas and Petrochem Equipment
Chemical and Engineering News
Environment
Journal of Water Pollution Control Federation
Pollution Engineering
Environmental Science and Technology
Water and Waste Engineering
Industrial Water Engineering

TABLE 6

TYPES, CAUSES AND REMEDIES FOR CHEMICAL SPILLS

CHEMICALS INVOLVED	FAILURE	PREVENTIVE MEASURES
Caustic Soda	Flexible pipe breaks loose while loading caustic soda into tankcar	Redesign loading device and install safety clamp Review facilities for handling hazardous chemicals
Ammonia	Scale tanks overfilled with ammonia; relief valve popped spraying liquid ammonia into atmosphere	Install high-level alarms on scales Install high-level cut-off valve on distribution tank
Aniline	Aniline stripper ruptures due to plugged vent line	Install double valves and tell-tale bleeds Install instrumentation-i.e. level and pressure recorders, alarms Redesign safety seal
Monomer	Tank overflow during filling; loss of 13,127 lb. of monomer; cause: plugged vent pipe	Inspect and clean vent pipe regularly
Sulfuric Acid	Hose bursts during transfer of acid	Do not use hoses for sulfuric acid loading; use pipes and swivel joints
Oleum	Rupture in flexible Teflon® hose; gasket failure	Install expansion valve Install pressure relief valve
Ammonia	Relief valve discharged improperly handled	Pipe discharge to ditch Line to vent pressure to keep pressure below relief valve setting
Caustic Potash	Drum overflowed into sewer; reacted with sulfides in sewer → H_2S	Redesign sewers to prevent "mixing" of hazardous materials that may react undesirably
Caustic Soda	Failure of gate valve and check valve	Redesign valves Redesign to prevent chemical contamination of steam and water supplies
Ammonia	Leaks in two manual block valves and automatic control valve	Replace/repair valves More frequent inspection
Phosphorous Acid	Failure of butterfly-type valve due to corrosion	Careful inspection of system Possible redesign of piping
Phthalic Anhydride	Tank overflow during filling	Install more reliable level indicators on tanks
Phosphorous Acid	Valve failure (defective valve)	Repair/replace valve
Sulfuric Acid	Hose rupture allows H_2SO_4 to enter sewer	Replace with permanent piping to appropriate drainage location
Sodium Sulfhydrate	Pump failure; sodium sulfhydrate enters sewer	Repair pump Install sump pump
Formaldehyde	Spring valve failed	Replace spring valve with gate valve
Phenol	Overloading of still due to failure of gauge	Redesign gauges to prevent inaccurate readings due to clogging
Sulfuric Acid	Leaking valve due to pressure buildup	Installation of vent line to relieve pressure buildups
Nitric Acid	Faulty hose connect and leaking cock in line	Replace hose with permanent pipe Replace/repair cock
Sulfates	Hot sulfate slurry overflows due to pump failure	Investigate different pumps to handle slurry
Toluene	Sight glass in stripper kettle line failed	Install new pressure-type sight glass Clean and inspect periodically Redesign to eliminate sight glass

TABLE 6 (Continued)

CHEMICALS INVOLVED	FAILURE	PREVENTIVE MEASURES
Caustic Soda	Failure of cock valve while caustic soda being loaded	Inspect cock valves before each use Redesign cock valve
Acrylonitrile	Water seals on reactor agitator blew	Redesign water seals Resize reactor vents to relieve pressure without blowing
Anhydrous Ammonia	Hose ruptured a fitting	Replace leaking block valve Install permanent piping
Sulfuric Acid	Cast iron pipe ruptures	Redesign piping system replacing cast iron pipes with PTFE-lined carbon steel piping
Hazardous, flammable chemical in polymerization reaction (pilot plant)	Safety disc rupture; escaping materials did not vent out proper vents	Temperature controller installed Review procedures to guard against future pressure buildups
Anhydrous Ammonia	Rupture of flexible hose on tank truck	Install check valve on tank line
Acid Cement	Frozen valve failed to bleed off pressure when opened; accumulation of cement prevented second valve from being closed	Replace valves Valves to be kept warm with use of propane heaters
Corrosive Chemical	Gate valve failure (valve stem)	Replace valves with more suitable type valves
Vinyl Chloride	Sight glass failure	Replace sight glass with one rated for pressures developed in reactor
Chloroacetic Acid	Mechanical failure of valve	Redesign valve
Acetanilide	Valve blows under pressure	New valve design
Ammonium Nitrate	Valve failure due to pressure buildup	Orifice restriction to be installed to limit flow
Phenol	Frozen valve; plugged cock	Inspection and repair of valves and cocks
Ammonia	Safety valve failure; failure of pressure gauge	Replace faulty valve; review design of gauge and possibly replace with better one
Liquid Organics	Overflow of surge tank	Installation of alarm to signal overfill
Sodium Cyanide	Dumping of cleaning agent in sewer	New treatment plant constructed
Methyl Alcohol	Tank truck wreck; contents spilled into river	--
Caustic and Peroxide	Pipeline failure	Repair and inspect pipeline
Unspecified Poison	Employee washed containers used for poison storage in river	Change housekeeping procedures
Textile Waste	Insufficient waste treatment plant	Reuse of plant waste and redesign of treatment system
Industrial Waste	Lagoon banks rupture	Reconstruct lagoon; fence in area
Adhesives	Spills into floor drains enter river	Divert waste to sewage disposal system
Acid Waste	Breakdown in lime pumps for neutralization resulted in acid waste discharge	Replace pump and add standby unit

Data Sources: References 16, 17, 18; Reports of Accidents maintained at the South Central Region Office of the Environmental Protection Agency.

The same type of accidents and causes are found in the list of types and causes of oil spills (Table 7) in Rhode Island during the period of July 1, 1968 to June 30, 1969, and for incidents taken from the Environmental Protection Agency's South Central Region Office. Thus, we conclude that the causes of spills are essentially the same regardless of country and geographical location and are primarily related to human error, either in design or operation.

The best documentation of failures of equipment and operational errors in handling hazardous materials was found in a systematic[20] survey of several hundred fires and explosions in the chemical industries over the past 20 years. On the basis of these case histories, the investigators suggested a series of hazards factors as the principal causes or contributors to these accidents. Although the study was concerned with fire and explosion losses, the same hazard factors often result in spills of hazardous materials. Those factors that we believe are most significant in spills of oil and hazardous materials are underlined in Table 8. Previous work[1,2,3,4] suggests that the last four causes given in Table 8--material movement problems, operational failures, equipment, and ineffective loss prevention programs--are probably the most important cause of spills of oil and hazardous materials. These hazard factors are well known to fire and safety engineers; careful consideration of them by environmental specialists may be an approach to help prevent spills.

B. EQUIPMENT, DESIGN CRITERIA AND PROCEDURES FOR SPILL PREVENTION

The results of our literature survey confirmed our original hypothesis that little specific technical information is available on equipment and design criteria solely for prevention of oil and hazardous material spills. Because liquid handling methods and systems are devised from equipment components, the most detailed design criteria and equipment specifications are based on achieving certain standards of design and fabrication to meet specified operational conditions. Furthermore, the specificity of these standards becomes more rigorous and the degree of permitted variability becomes less broad for either unusual operating conditions, e.g., temperatures and pressures significantly above or below ambient, or where hazards to property and personnel are high such as from fire or toxicity.

Literature references on equipment are principally restricted to containment and removal devices for spilled oil and not on equipment for spill prevention. We determined that the best approach to the equipment aspect of spill prevention is adherence to manufacturing, construction and performance standards commensurate with the potential for spills to occur and to enter water resources because the literature[16,17,18] indicated that spills could not be overcome solely through reliance on improved equipment and because of the impracticality of devising generally meaningful equipment configuration and designs for all spill prevention problems.

TABLE 7

TYPES, CAUSES AND REMEDIES FOR OIL SPILLS

SPILL TYPE	FAILURE OR CAUSE	CORRECTIVE ACTION *
Black oil in river	Vandals emptied fuel tank into plant floor drain; entered river	Place valve in floor drain
Black oil in river	Breakdown of heating unit causes oil to be discharged through floor drain	Use separator for floor drain
Black oil in river	Break of fuel oil coupling in plant, oil discharged through drain	Terminate floor drains in dry sump
Oil at wharf	Improperly maintained oil spearator leaked	Repair or replace separator
Light fuel oil at terminal	Leaky hatch cover	Mechanical repairs
Light fuel oil	Pipeline rupture of unknown cause	Build retaining walls around pipeline and transfer pumps
Heavy fuel oil	Barge went aground	--
Heavy fuel oil	Overflow of storage tank during transfer; flowed through yard drain	Seal yard drain
Heavy fuel oil	Improper ballasting procedure caused spill of oil	--
Light fuel oil	Overflow storage tank, valve in diked area left open	Close valve; update inspection procedures
Bunker C	Tank overflow during storage	--
Crude oil	Pipeline break caused by pile driving in area	--
Crude oil	Heater-treater malfunction	--
Crude oil	Oil in dike from overfilled tank; dike valve open	--
Crude oil	Storage tank rupture, dike valve open	--
Crude oil	Drop in high tide resulted in siphoning oil from separator	--
Crude oil	Farmer broke pipeline while plowing field	--

* Recommended in state report.

TABLE 8

HAZARD FACTORS IN CHEMICAL PLANTS

PROBLEM	FACTORS	EXAMPLES OF HOW FACTORS COULD AFFECT SPILLS
1. Plant Siting	• Unusual exposure to natural forces such as windstorms, floods, earthquakes	• Weathered contaminants could be washed into drains
	• Poor location with respect to water and utility supplies	• Insufficient wash water available
	• Hazards from nearby plants	• Hazards could cause spill situations
	• Unreliable public fire and emergency protection	
	• Difficult traffic conditions for emergency equipment	
	• Inadequate waste and disposal facilities	• Incomplete cleanup of process waste
	• Climatic conditions requiring indoor installation of hazardous processes.	
2. Plant Layout	• Congested process and storage areas	• Insufficient room for curbing or dikes
	• Inadequate isolation of extra hazardous operations	
	• Exposure of high-value, difficult to replace equipment	
	• Lack of proper emergency exits	
	• Insufficient space for maintenance or emergency operations	• Poor maintenance could lead to chronic leaks
	• Ignition source too close to hazards	
	• Critical plant areas exposed to hazards	• Fire or explosive hazards could cause spills in adjacent areas
	• Inadequate designation of plant hazard areas	
3. Non-Conforming Structures	• Disregard of building codes	•
	• Inadequate fire restrictive structural supports	
	• Failure to provide blast walls or cubicles for extra hazardous operations	
	• Inadequate explosion venting	
	• Inadequate building ventilation	
	• Insufficient exits	
	• Electrical equipment not in conformance to required codes	
4. Material Evaluation	• Insufficient evaluation of fire, health and stability characteristics of materials	• Inadequate materials usage could yield spills, e.g. incorrect materials of construction for storage
	• Lack of established control for quantities used	• Excess quantities of materials could exceed prevention measures, e.g. dikes, sumps
	• Inadequate assessment of processing conditions on hazardous characteristics	• Processing could change commonly spilled non-hazardous materials to hazardous
	• Lack of information on dust explosion potentials	
	• Toxicological hazards not properly evaluated	
	• Incomplete inventory of hazardous materials	• Can lead to inadequate spill prevention plan
	• Improper packaging and labeling	
5. Process	• Lack of information on effects of process temperature and pressure variations	• Could lead to spills from process equipment
	• Lack of information on hazardous by-products or side reactions	• Materials of unkrown hazard could be spilled
	• Inadequate knowledge of process reaction rates	
	• Failure to identify possible explosive reactions	
	• Inadequate evaluation of environment	
	• Failure to provide for extreme process conditions	

TABLE 8 (Continued)

6. **Material Transport**	• Lack of control during processing	• Spills from processing units could occur
	• Inadequate controls for dust hazards	
	• Piping problems	• Could result in chronic piping leaks
	• Improper identification of hazardous materials	
	• Loading and unloading operations	• Could result in spills at loading/unloading areas
	• Flammability	
	• Heat transfer control	
	• Pneumatic conveyor explosions	
	• Waste disposal and air pollution problems	
7. Operations	• Lack of detailed operating instructions and procedures	• Can lead to open valves, unwanted discharges etc.
	• Inadequate operator training programs	
	• Poor supervision	
	• Inadequate start-up and shut-down procedures	• Unexpected spills are common in start-up and shut-down
	• Poor inspection and housekeeping programs	
	• Inadequate operating permit program for hazardous materials	
	• Lack of emergency control plans	• Spill control plan lacking
	• Inadequate drills in operating emergency procedures	
8. Equipment Failure	• Hazards inherent in design	• All equipment failure factors which can result in fires can result in spills
	• Corrosion or erosion	
	• Metal fatigue	
	• Defective fabrication	
	• Inadequate control	
	• Process conditions exceeded design limits	
	• Poor maintenance	
	• Inadequate repair and replacement	
	• Lack of "fail-safe" instrumentation	
	• Inadequate inspection for adherence to construction criteria or material specifications	
9. Loss Prevention Program	• Lack of assigned responsibility	• Operations may not have been given responsibility for factors which could cause spills
	• Ineffective explosion prevention and control programs	
	• Lack of emergency plans	
	• Poor check on boiler and machinery risks	
	• Poor coordination of operating group with other plant groups	• Spill prevention must be integral part of plant operations
	• Ineffective accident investigations	

Standards for mechanical, electrical, fabrication, chemical and performance can be found among the societies shown in Table 9 to meet virtually any desired specification. These vary from standards such as nominal diameter, material, and type of connection for small diameter piping to detailed codes for the manufacture of pressure vessels subjected to independent certification. Our literature survey of equipment and design criteria confirmed the availability of types of equipment, materials of construction, design criteria, and manufacturing standards to achieve the construction of high integrity liquid handling systems. Consequently, the major efforts of our literature search were devoted to determining what spill prevention procedures existed.

The most pertinent literature references for spill prevention and control through specified operational procedures are based on controlling substances classified as hazardous because of the potential for fires and explosions or because of human toxicity. Safety in the petroleum and chemical industries has received the most attention by organizations such as the American Petroleum Institute, Manufacturing Chemists Association, Underwriters Laboratories, American Insurance Association, and the National Fire Protection Association. Technical publication of these organizations are oriented toward procedures and standards for equipment manufacture, installation and operation for preventing fires and explosions and for providing for personnel safety and minimizing property damage. These reports and studies present both detailed and broad general guidelines and specific procedures for fire protection. Typical examples of the subjects covered are shown in Table 10. None of these procedures and standards are directed toward spill prevention from the viewpoint of environmental protection; however, many of these fire and hazards prevention procedures will indeed prevent spill pollution incidents. The following is an example of a typical code[21] which has applicability to prevention of pollution by oil and hazardous materials.

> "Drainage and Diked Areas: The area surrounding a tank or a group of tanks shall be provided with drainage as in Paragraph 2172, or shall be diked as provided in Paragraph 2173, to prevent accidental discharge of liquid from endangering adjoining property or reaching waterways, except that in particular installations these provisions may be waived or altered at the discretion of the authority having jurisdiction when the tanks under consideration do not constitute a hazard to adjoining property."
>
> "...The drainage system shall terminate in vacant land or other area or in an impounding basin having a capacity not smaller than that of the largest tank served. This termination area and the route of the drainage system shall be so located that, if the flammable or combustible liquids in the drainage system are ignited, the fire will not seriously expose tanks or adjoining property."

TABLE 9

PROFESSIONAL GROUPS ESTABLISHING EQUIPMENT AND FABRICATION STANDARDS PERTINENT TO SPILL PREVENTION

American Petroleum Institute

American Society of Mechanical Engineers

American Society for Testing and Materials

U. S. A. Standards Institute

American Water Works Association

American Iron and Steel Institute

American Welding Society

Association of American Railroads

Valve Manufactures Association

Welding Steel Tube Institute

Manufacturers Standardizations Society of the Valve and Fittings Industry

National Association of Pipe Nipple Manufacturers, Inc.

National Certified Pipe Welding Bureau

Pipe Fabrication Institute

Tubular Exchanger Manufacturers Association

Manufacturing Chemists Association

Society of Automotive Engineers

Hydraulic Institute

TABLE 10

TYPICAL PUBLICATIONS ON HANDLING FLAMMABLE AND HAZARDOUS MATERIALS

SPONSORING ORGANIZATION	TITLE
American Petroleum Institute	Recommended Practice for Cleaning Petroleum Storage Tanks
American Petroleum Institute	Recommended Practice for Cleaning Tank Vehicles Used for Transportation of Flammable Materials
American Petroleum Institute	Guide for the Storage and Loading of Heavy Oil, Including Asphalt
American Petroleum Institute	Practices for Bulk Liquid Loss Control in Terminals and Depots (covers evaporated losses)
Manufacturing Chemists Association	MCA Cargo Information Card--Manual for Bulk Dangerous Cargoes
Underwriters' Laboratories Standards for Safety	Hose for Conducting Gasoline
Underwriters' Laboratories Standards for Safety	Steel Underground Tanks for Flammable and Combustible Liquids
National Fire Protection Association	National Fire Codes, Volume I, Flammable Liquids
American Insurance Association	Highway Transportation of Extra-Hazardous Commodities
American Insurance Association	Liquefied Petroleum Gas, Safe Handling and Use
American Insurance Association	Supervisor's Safety Memo, Emergency Planning; and Supervisor's Safety Memo, Accident Prevention
National Board of Fire Underwriters	Processes, Hazards and Protection Involved in the Manufacture of Spirituous Liquors
National Board of Fire Underwriters	Fire Hazards and Safeguards for the Metal Working Industries
American Petroleum Institute	Safe Maintenance Practices in Refineries
American Petroleum Institute	Tank Vehicle Bottom Loading and Unloading

> "...Where provision is made for draining water from diked areas, drainage shall be provided at a uniform slope of not less than one per cent away from tanks toward a sump, drainbox or other safe means of disposal located at the greatest practical distance from the tank. Such drains shall normally be controlled in a manner so as to prevent flammable or combustible liquids from entering natural water courses, public sewers, or public drains, if their presence would constitute a hazard. Control of drainage shall be accessible under fire conditions."
> "Piping systems shall contain a sufficient number of valves to operate the system properly and to protect the plant. Piping systems in connection with pumps shall contain a sufficient number of valves to control properly the flow of liquid in normal operation and in the event of physical damage. Each connection to pipe lines, by which equipment such as tank cars or tank vehicles discharge liquids by means of pumps into storage tanks, shall be provided with a check valve for automatic protection against back-flow if the piping arrangement is such that back-flow from the system is possible."

The literature on procedures for detection, prevention and control of spills is primarily focused on oil and petroleum products. These procedures are most often incorporated in rules and regulations, such as reviewed in Chapter III, or in publications of professional societies dealing with the control of waste water influence from industry. For example, a report by the American Society of Lubrication Engineers[22] defines the oily-waste control program and methods for evaluating the quality of the program. It discusses control of oily waste generation at the source and presents general procedures for prevention and control of oily-waste pollution. Two examples of problems and solutions have been condensed into Table II. The overall picture that developed from our literature surveys showed that most procedures for spill prevention and control programs must be based on design criteria, engineering judgment, facility construction and good housekeeping procedures. An increasing need to step back and take an "unbiased view" of the operations from a number of viewpoints such as pollution potential in case of fires, power failures, flooding or other natural disasters, sabotage, operator inattention, and so on, has resulted in a check list such as given in Table 12.[23] An example of a simple safety check list for heater operations, transport and storage in the chemical and allied industries is shown in Table 13, taken from a hazard survey[20] by the American Insurance Association. It is apparent that a system designed to be "fail-safe" will be less prone to pollution causing incidents when spills of hazardous materials occur under less severe circumstances.

TABLE 11

CASE STUDY EXAMPLES OF PROCEDURES FOR OVERCOMING OIL POLLUTION

PROBLEM	SOLUTIONS
Petrochemical plant located on Gulf Coast Bay was discharging excessive amounts of oil in waste water stream. All plant effluent passed through a single API Separator--including process, cooling and storm water. Only sanitary wastes were segregated in separate sewers.	• Barometric condensers were replaced with indirect heat exchangers • Effluent from one process unit, a reformer, was sent to a primary sedimentation basin from which oil and sludge were collected. • Storm drainage from tank storage area was diverted through an open channel into a holding lagoon before discharge to bay. • A floating boom and rotating, cylindrical collector was used to remove oil from lagoon. • Process water usage was reduced. • Interconnections between process and storm sewers were blocked. • All surface drainage from the process plant area, all uncontaminated cooling water and boiler blowdown were diverted through one chamber of the API separator. • Remaining process water was sent through other chamber of API separator, combined with sanitary sewage and put through a trickling filter. • Oil removed at various point was collected and incinerated. • API Separator efficiency was improved through modifications. • Waste treatment operators were given careful instructions on operational procedures.
A fuel oil storage facility on the Ohio River had received heavy local criticism from citizens and municipal water treatment plant operators because of both chronic and major spillage of oil.	• Investigations established that most of oil pollution occurred during transfer of oil from barges to storage tanks. • All hoses, couplings and connectors were inspected. • Hoses with pinholes were replaced, gaskets and connectors were replaced and made fully operable. • Operators were instructed in careful handling of hoses and to drain all hoses back into the barge after completion of pumping. • Drip pans were provided under all connections. • When operating valves, operators were instructed in procedures to insure proper seating. • Proper supports were provided for hoses. • Storage of hoses in a manner to prevent accidental damage and leakage were devised. • Securing of barges was improved to insure that no undue strains were placed on hoses and connectors due to movement. • A tank truck was provided into which all accidental oil could be placed. • A floating boom and oil skimmer was purchased and maintained ready to use.

TABLE 12

TYPICAL CHECKLIST FOR PROCESS EXAMINATION

FOR THE OVERALL PROCESS

1. List all highly toxic materials used or formed in the process. For each material:

    - List the conditions necessary for it to be released to the atmosphere or to surface or underground waters. (Does it normally occur in the process as a vapor, as a highly volatile liquid, as a nonvolatile liquid, or as a solid? If it is not easily vaporized, what process conditions could cause it to be sprayed into the atmosphere as a liquid aerosol or dust cloud?)

    - List the time-concentration levels in the atmosphere that will produce an effect on human health. List the exposure level in water as a function of event duration at which toxic effects to marine life and to human health become apparent. Are the toxic effects reversible or permanant?

2. For all materials used or produced in the process and other nearby processes, consider chemical reactions that could take place in the atmosphere or in sewers and streams between possible chemical species to produce other highly toxic materials not present in the process. For any such compounds that could be produced, list the same information as for Item 1 above.

FOR CONSIDERATION OF INDIVIDUAL PROCESS ITEMS REQUIRING DETAILED STUDY

1. List those pieces of equipment containing sufficient toxic material to produce a hazard if their contents were suddenly released to the environment.

2. List those items that could produce hazardous quantities of toxic material through interaction if the contents of two vessels were released simultaneously.

3. List equipment containing design elements likely to leak hazardous materials such as pump packing, tank vents--or leaks that might be caused by corrosion of equipment, etc. For each item listed, indicate what safeguard has been taken to prevent normal leakage, such as packless pumps, double rotary seals, vents connected to a scrubber, etc. Is each safeguard adequate and reliable?

DETAILED STUDY

For each item retained on a list under the individual process items, consider the following:

1. For each process vessel:

    - What are the utilities required? What could happen if one of these utilities were suddenly and permanently interrupted? If temporarily interrupted?

    - What would happen if the flow of one or more of the process streams entering or leaving the vessel were interrupted? What if it were twice the desired quantity? What would happen if the normal outlet connections from the vessel became plugged?

TABLE 12 (Continued)

- Is the collection efficiency adequate to prevent hazardous conditions under normal operating conditions? What abnormal plant conditions can impose the greatest load on this equipment? For how long is it possible for these abnormal conditions to persist? What would be the collection efficiency under these conditions of increased or decreased flow? Would it be adequate?

- What would happen in case of utility failure or flow stoppage (loss of motive force collection device?

- What would happen to the collection device if surrounded by fire? Could it suffer an internal fire? What then?

- What can happen on collection- malfunction?

- In case of a small leak caused by corrosion, what would happed to the leaking material? Would it produce an environmental hazard? How long might it leak before being detected? Would the leak hasten the corrosion and failure of the vessel?

- In case of failure of the vessel, how would the content be contained? If volatile, what would be done to prevent its vaporization?

- What would be the effect of overpressure? If protected by overpressure release devices, how would the materials released be contained? What would be the effect of overheating? Of overcooling? Could the vessel be surrounded by flames from burning material released because of failure of other equipment in the area? If so, what would happen if the fire lasted for many hours?

- What would be the effect on vessel and contents from sudden plant flooding, violent storms, or earthquake?

- What operator error or instrument failure could endanger the loss of vessel contents?

2. For instrumentation on equipment that handles hazardous materials:

    - What would happen upon power or motive force failure to one instrument, or a group of instruments? To all instruments? What position would control valves seek? Is this the best position to minimize hazards?

    - For each instrument, what can happen in case of sensor failure? In case of control valve seizing? Would the operator receive warning in time to take corrective action? Should it be clear to a poorly trained operator what corrective action is needed, or can the situation be handled with built-in automatic overrides?

3. For material-collection, containment or pollution-prevention equipment (scrubbers, dust collectors, condensers, flares, combustion incinerators, etc.):

TABLE 13

CHECK LIST FOR HEATER, COMMON TRANSPORT AND STORAGE OPERATIONS

1. Have the potential hazards of all materials involved been evaluated?
2. Are precautionary measures taken to guard against accidental release of flammable or toxic liquids, gases or combustible dusts?
3. Are unstable chemicals handled in such a way as to minimize exposure to heat, pressure, shock or friction?
4. Are the unit operation facilities properly designed, instrumented and controlled to minimize losses?
5. Have all heat transfer operations been properly evaluated for hazards.
6. Have all transport operations been checked for operator safety?
7. Are shipments of chemicals from the plant packaged, labeled and transported in accordance with current regulations?
8. Are waste disposal and air pollution problems handled in accordance with current regulations?

From this survey we conclude that the most detailed design criteria, equipment specifications, and operational procedures are for either unusual operating conditions, e.g., temperatures and pressures significantly above or below ambient, or where hazards to property and personnel are high such as from fire or toxicity.

C. INDUSTRIAL UTILIZATION OF SPILL PREVENTION AND CONTROL TECHNIQUES

Literature sources provided no basis for establishing the frequency with which industry utilizes available techniques for prevention and control of spills in its handling of hazardous substances. The only spill control technique that could be ascertained as used with high frequency is dikes around tanks holding flammable materials. However, the usage of dikes is primarily to meet fire and safety regulations. Consequently, it was concluded that the type and frequency of industrial utilization of spill prevention and control equipment and techniques would have to be developed from plant inspections.

V. FIELD SURVEY

A. METHODOLOGY

For our field surveys we selected facilities to obtain a cross-section of geographical locations and types of processing industries. We included large integrated plants with continuous operations, for example, petroleum refineries; plants handling small volumes of hazardous polluting substances, for example metal plating; and plants handling a multiplicity of substances. In other studies we had developed inventories of major transport, transfer, and storage facilities for hazardous polluting substances at four geographical locations in the United States: Texas City, Texas; Baltimore, Maryland; Charleston, West Virginia; and San Pablo Bay and Suison Bay, California.[24,25] Inasmuch as these areas had been surveyed rather thoroughly, we selected additional sites to survey practices and procedures in order to complement the earlier work: New York - New Jersey, Houston, Texas, Los Angeles and San Francisco, and Illinois - Michigan.

Using our experience in process design and project management and the experience of our past surveys, we established an outline of the pertinent questions to ask and the types of observations to be made. (See Appendix E.) We also discussed with process design and construction companies (architect-engineering firms) the spill control procedures they incorporate in their designs. We visited a number of local and state regulatory groups, as well as the Environmental Protection Agency Regional staff, and discussed the need for additional regulations as envisioned by these groups.

In our survey and discussion program we contacted 37 companies and organizations. At many of the individual facilities, we observed several different operations or manufacturing processes; for example, bulk oil storage and distribution was often a part of an oil refinery storage and complex at which site petrochemicals were also being manufactured. The surveyed facilities cannot be separated easily into concise categories because of the complexity of the process operations, the number of locations at which hazardous polluting substances were handled, and the number of these substances. Consequently, we have listed the number of facilities and groups under eight general categories (Table 14). However, the total is greater than the number of visits because of the multiple operations that were often found.

As we visited the plants and analyzed and compiled the data obtained, it became clear that the results could be presented and summarized in at least three ways: by type of industry; by type of prevention approach--design criteria, procedures, equipment, etc.; and by "unit operations"--storage, transfer processing, etc. Of the three, we selected the last. The first method would present information from only a few sources thought to be representative of large industrial sectors. It could easily lead

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TABLE 14

FACILITIES, AGENCIES AND ORGANIZATIONS VISITED IN FIELD SURVEY

	Bulk Oil Storage and Distribution	Oil Refinery Storage and Complex	Petro-Chemical	Chemical	Rubber or Plastics	Metal Products	Regulatory Agencies	Plant Designers and Constructors
Badger Company, Inc.								X
Stone and Webster Engineering Corp.								X
The Lummus Company								X
Fluor Corporation								X
Bechtel Corporation								X
Texas Water Quality Board							X	
Texas Railroad Commission							X	
California State Water Control Board							X	
California Fish & Game							X	
EPA--Edison Lab							X	
EPA--Pacific Division							X	
Louisiana Wildlife & Fisheries Com.							X	
Metropolitan San. Dist. of Chicago							X	
Goodyear Chemical Company				X	X			
Ethyl Corporation			X	X				
Atlantic Richfield Company	X	X	X					
Shell Chemical Company			X	X				
Mobil Oil Corporation	X	X						
General Motors Corporation						X		
Dow Chemical Company				X				
Union Oil Company	X	X						
Proctor and Gamble Company				X				
U. S. Steel Corporation						X		
General American Transportation Corp.	X							
Standard Oil Company of California	X	X	X					
Hercules, Inc.				X				
Curtiss-Wright Corporation						X		
Amerada Hess Corporation	X	X						
Humble Oil and Refining Company (2 loca-	X	X	X					
Humble Oil and Refining Company tions)	X	X						
Stauffer Chemical Company				X				
The Upjohn Company				X				
Enjay Chemical Company			X	X	X			
U. S. Industrial Chemicals Company				X				
Olin Corporation--Agricultural Division				X				
Du Pont Company			X	X				
TOTAL	8	7	7	12	2	3	8	5

to repetition because many prevention methods are similar throughout industry. In the second, we would face the inherent difficulty of trying to decide whether a "prevention practice" is a design criterion, equipment, or a procedure. For example, is the use of a dike with a closed drain valve around an oil tank a design criterion or an example of equipment; is the practice of closing the valve an operational procedure?

We found that the industrial facilities we visited could be readily classified into unit operations: storage, transfer, loading and unloading, processing, and waste treatment. Each type of unit operation has basic elements or spill prevention techniques regardless of the type of facility or products handled. Thus we have summarized the results of our surveys in terms of these operations even though the details of practices used at each facility were expected to differ. Finally we have combined the results of this survey with those obtained in earlier investigations to obtain a better overview of the spill prevention measures presently used by industry.

B. SURVEY RESULTS

The results of the field survey are presented in a series of tables given in Appendix F. Each table in Appendix F lists the major design criteria, operating procedures, and equipment used at each facility for the prevention of spills of oil and other hazardous materials. In some facilities, it was not difficult to determine the principal practices used; in others, the concern of the plant management for outside visitors or the proprietary nature of the operations may have prevented full disclosure of all the measures used. Also, we found that in some facilities equipment and procedures which could be used to prevent spills were considered routine and not specifically mentioned by the facility personnel. Thus, these tables are not totally complete. Of course, one would expect a considerable variation of methods and equipment because of the diversity of types, locations, ages of the facilities visited, and the different processes and hazardous materials used.

In order to make a more comprehensive presentation of the results of the plant visits, we have summarized in tabular form the principal design criteria, equipment, and procedures we observed in each operational area--storage, transfer, loading and unloading, processing and waste treatment. The tables show the number of facilities in which we observed each practice; this provides an indication of the acceptance of this practice by industry. The number should not be regarded as precise, but shows the relative use of the different practices. A brief discussion of the practices is also given. Another table is given to summarize "management procedures" which plant management personnel thought were effective in preventing spills of oil and hazardous materials.

1. Storage

Table 15 summarizes the major practices for spill prevention in storage areas. In addition to these, at least one facility used each of the following practices:

- Log of condition of valves on all tanks and dikes
- Impermeable membranes around tanks
- No bottom pipe connections in tanks
  (load and unload from top entry pipes)
- Gravity loading of tanks

We note that none of these procedures is fail safe by itself; a combination of design criteria, procedures and equipment is required.

a. Spill Prevention

Because storage tanks have a very long service life, most facility operators inspect tanks for corrosion and weakening by nondestructive and destructive testing methods. Visual inspection from the outside of the tank is often coupled with other routine maintenance, such as painting, but unfortunately is not regularly scheduled in most facilities. Ultrasonics is a good, but very time consuming and tedious means of determining the wall thickness of a tank non-destructively. This method is applicable to an empty or filled tank but normally is used for spot checks rather than to scan the entire area of the tank.

Although diligent inspection can prevent a corrosion-induced tank rupture, a tank may fail because of the pressure differential created between the inside and outside when the tank is emptying and the vent becomes clogged. This kind of catastrophic spill event can be prevented by simple maintenance and inspection of vents and vent lines on storage tanks, to insure that they are open, and also by monitoring pressure in the vapor space at the top of these tanks. The vapor space pressure was not measured in any of the facilities we visited; however, a low pressure alarm system could prevent the occurrence of this infrequent, but catastrophic spill event.

Spills resulting from overfilling a tank can be avoided with a gauging system that displays or indicates the instantaneous liquid level in the tank--such information is acted upon by the personnel charged with controlling the operations of the storage facility. However, these types of level indicators and associated transmission and read-out instrumentation were found not to be used frequently because of malfunctions. A more universal procedure was for plant personnel once each day to measure the liquid level in each tank by means of a dipstick. Plant operators believe this kind of activity not only prevents accidental

TABLE 15

SUMMARY OF SPILL PREVENTION PRACTICES IN STORAGE AREAS

PRACTICE	TYPE	NUMBER OF FACILITIES*	REMARKS
Dikes, fire walls, or earthen barriers around tanks	Design criteria, equipment	21	Usually required by fire codes; may be used only for flammable or hazardous materials
Drainage ditches and graded surfaces surrounding tanks	Design criteria	7	Ditches may be part of the storm water sewer or process sewer systems
Manual gauging of storage tanks at regular intervals	Procedure	7	Dip sticks used as positive level measure; often prior to and after transfer
Separate drainage system for diked tanks	Design criteria	6	Any spills in and around diked area can be diverted to retention ponds or other facilities without overloading waste treatment facilities
Planned inspection of all tanks, dikes and equipment in storage area at regular intervals	Procedure	5	Frequently a written inspection plan by maintenance staff to examine area for potential failure points
Automatic level gauging in tanks; or gauging manifolds	Equipment	5	Measurement system to display tank contents to operator in central location
Automatic high and low level alarms (or pressure alarms) for storage tanks	Equipment	4	Most alarms indicated in central control rooms or supervisory locations which are manned 24 hours/day
Specified procedures for removal of rain water from diked areas	Procedure	4	Insures that dike valves are normally closed and prevents spills from emptying into waste treatment stream
Locked or sealed valves on drain lines in diked areas	Procedure	3	Prevents spills from leaving diked area
No drain lines in diked area; sumps and pump out systems used	Design criteria equipment	3	Both rainwater and spilled material must be pumped to treatment area
Equipment (trucks) available (mandatory) during tank cleaning	Equipment Procedure	3	Prevent release of sludge or waste, and reduce waste runoff during next rain
Written procedures followed in transferring to or from all storage tanks	Procedure	2	Other facilities had procedures for special situations or materials
Spare tanks or catch basins specifically designated for e storage tank	Procedure Design Criteria	2	These could be used in emergency situations
Specific overflow lines from storage tanks to sumps or catch basins with alarms	Design Criteria Equipment	2	Provides both indication of overfilled tank and prevents loss of material
Tank contents analysed before transfer	Procedure	2	Basically a safety measure to prevent mixing hazardous materials and loss of product quality

* A total of 23 facilities were visited.

overfill but also helps to detect a leak which might go unnoticed during the normal routine. The measurement also detects errors in or malfunctioning of instrumentation and control equipment used to operate the tank farm facility. Level alarms on tanks were not observed often in our survey, apparently because of questionable reliability of these systems. Two of the five architect-engineer firms we visited recommended automatic gauging or alarms.

Storage tanks used for crude petroleum and certain other organic intermediate and refined products collect a heavy thick sludge on the tank floor and must be drained periodically and cleaned. Several facilities we visited have well established procedures for the cleaning process, including the use of vacuum trucks for removal and precautions to insure that any excess spilled material will remain in the diked area or be treated effectively in a waste handling system.

b. Spill Detection

The only effective way of detecting spills in storage tank areas reported in our survey is planned visual inspection by the operating personnel frequenting the area. Discussions with architect-engineering firms, and with several companies in the chemical processing industries indicate that good design in storage tank farm facilities includes the strategic location of one or more instruments or controls which require the periodic checking and data recording by plant personnel. These controls are deliberately located in such a way that plant personnel must periodically traverse the storage tank farm area and thus help insure rapid visual detection of leaks. This is a good example of current state of the art, where good design practice is short of total automatic data acquisition and transmittal and process control, and where the human element deliberately included as a "fail-safe" aspect.

The larger and more modern storage tank farm facilities are now being designed with sensing devices such as liquid-level detectors in all of the tanks, with data transmission systems connected to a central control room. A computer can keep track of an instantaneous inventory and material balance and show any spill of sizable proportions as an unaccountable loss. Although the computer system is used primarily for inventory control, the potential for spill detection is inherent in the system. One of the facilities we visited was in the process of installing such a system. Another plant was considering the use of closed circuit T.V. to help detect spills in storage areas.

c. Spill Control

Insurance, safety, and fire codes typically require that aboveground storage tanks used for flammable liquids be surrounded by a fire wall or dike sufficiently high (with some maximum height normally specified) to contain at least 100% of the maximum storable or usable tank volume. Fortunately these dikes also provide the primary means of spill control in storage areas. In almost all of the facilities we visited, tanks containing oil were diked. Those containing flammable organics were also diked, but those containing inorganic materials were usually not diked, even if their contents were hazardous.

Dikes are usually penetrated by one or two drainage lines equipped with shutoff valves on the outside of the dike or fire wall. These valves should normally be closed, so that spills and contaminated rainwater do not flow into undesirable channels. Inspection, valve locks, seals and other means were used in several facilities to assure this does not happen. Another approach used in a few small facilities was a sump and pump operation to drain dikes, thus precluding gravity flow of spilled material. After a heavy rainfall, plant personnel normally inspect the rainwater contained in each dike for evidence of contamination. Several facilities had detailed procedures for sequentially discharging rainwater after inspection. In most facilities, if the water appeared clean it was sent directly to clean-water discharge from the plant. In several facilities, the discharge from diked areas was routinely sent to the waste treatment facility, a more conservative and fail-safe approach.

Dikes or fire walls can be very effective means for controlling small spills or leaks from storage tanks. However, the normal dikes or fire walls used today have been totally ineffective in containing some major and catastrophic leaks from large storage tanks which resulted in the generation of a large high-velocity jet of liquid issuing from the side wall of the tank. Such spills have been known to rapidly wash out a dike at which it was directed and render the dike ineffective. Also the high level of kinetic energy associated with a large jet of liquid issuing from the side of a storage tank has been known to cause a jet of liquid to simply wash over the top of a dike, since dikes are designed to restrain and confine a gradually deepening pool of liquid rather than a stream of liquid moving a high velocity. Evidence is now accumulating that dikes require more engineering consideration due to their failure to withstand shock loading. Reinforcement and overhang design should aid in controlling dike failures.

A backup control system found in about one-fourth of the facilities we visited was to use drainage ditches around the storage area which were either (1) separate from the remainder of the plant or (2) formed a part of the chemical waste disposal system. Thus any leaks from the storage area, or leaks through valves in dikes, would be conveyed to a waste treatment facility rather than discharged with storm water.

2. Transfer

Table 16 summarizes the major practices for spill prevention in the transfer process. (As noted in the Introduction, we have defined transfer as the piping between storage and process areas, and related pumps, etc. Other practices are given later which are more specific to loading and unloading areas.) In addition to these, one or two facilities used the following:

- Flange bonnets on all pipeline flanges
- Samples analyzed prior to transfer in line
- Planned attempt to reduce the number of flanges in pipelines
- Low pressure shut off in pipelines

Two of the architect-engineering firms visited recommended above grade piping throughout the plant with appropriate drainage system underneath. All of the architect-engineering firms visited recommended welded piping systems for both process and transfer areas to help reduce leaks from flanges.

a. Spill Prevention

Management personnel of the facilities we visited indicated that preventive maintenance is a necessary and most effective means of preventing spills from failure of pipes, pumps, valves, and other components. The proximity of a large number of pipelines running a parallel course on common supporting structures greatly facilitates routine painting and inspection programs. Surveillance by plant personnel is generally intensified on those pipe transfer systems whose color code indicates that they carry the more hazardous liquids. Therefore, the visual examination of pipelines is probably increased in direct proportion to the hazard of the liquid being transferred. Another form of preventive maintenance found useful to some plant operators is routine inspection and periodic replacement of components which past operating practice has indicated have a limited service life--for example, valve seals and shaft seals on pumps, which wear out with a rather predictable frequency. Use of welded pipe joints rather than flanges helps eliminate part of this problem.

TABLE 16

SUMMARY OF SPILL PREVENTION PRACTICES IN TRANSFER AREAS

PRACTICE	TYPE	NUMBER OF FACILITIES*	REMARKS
Planned periodic inspection of all pipelines, combined with preventive maintenance	Procedure	8	Most inspections include some hydrostatic pressure tests or ultrasonic tests
All pipelines located above grade to facilitate inspection and identification of leaks	Design criteria	8	Generally found in newer facilities
Concrete ditches under pipelines, lead to chemical waste system or waste water system	Design criteria	5	In most cases, these act to drain plant area as well as conduct any spills to treatment area
Plant procedures require operators to walk pipelines on daily basis for inspection	Procedure	3	Strategic placement of valves, meters, etc. require operator to survey pipeline
Pressure relief valves in portions of pipeline	Equipment	2	These were not fail-safe measures in themselves, but valve opened to channel which led to waste treatment facility
Written procedures for pipeline transfer	Procedure	2	Also, telephone procedures for several plants with long pipelines or inter-plant pipelines
Leak detection system using computer monitored flow meters and tank level indicators	Equipment	2	These systems were found in large refinery operations
Check valves and storage tanks at ends of pipelines specifically for spill prevention and control	Equipment	2	
Cathodic protection system for underground pipelines	Design criteria	2	Most likely many facilities used cathodic protection but only 2 indicated that it was a spill prevention measure

*A total of 23 facilities were visited

Another prevention practice we observed in several facilities is the use of seals on valve handles which normally should remain in some particular position. Any movement of the valve handle breaks the seal and alerts operating and maintenance personnel that the valve is no longer in the desired position.

Several plants use written procedures for transfer of fluids by pipeline. This practice seems to be becoming more standard.

b. Spill Detection

Simple visual inspection is the most commonly used means of detecting spills associated with transfer of liquids. Plant personnel frequently travel along and under the pipe racks. Pipeways are often laid out not only so personnel can easily inspect them but also so personnel must frequently pass the pipeways on their way to perform other unrelated tasks. This practice increases the exposure of plant personnel to the actual physical transfer pipeline facilities.

Unfortunately, newer and highly automated production plants are designed to be staffed by a minimum of personnel. It is not uncommon for a large, highly automated chemical plant to be operated by five to ten operating personnel who spend a large part of their time in a central control room. Therefore, an accidental event such as the rupture of a pipeline might be detectable only through data transmitted to and displayed within the control room--drop in pressure or a change in flow rate for example. Only a few of the plants we visited had enough monitoring equipment for routine detection of pipeline spills from control rooms.

Classical inventory control permits detection of spills in some plants. The more refined, accurate, and frequent the inventory balances, the more quickly a spill can be detected, and the more sensitive the technique is to detecting even smaller spills. The availability of large and effective digital computer systems to industry has made possible the means for maintaining almost continuous and very close surveillance of the flow rates of liquid into and out of all the active pipelines at a large chemical-processing plant. Two of the plants we visited have installed such systems, several others were considering developing this kind of system capability. The primary purpose for this kind of inventory control system is to optimize the utilization of production facilities and the scheduling and movement of liquids and various bulk carriers to and from the plant. A direct "spin-off" of this kind of monitoring and surveillance system, however, is the potential for detection of spills.

A simple, yet apparently effective, approach that we found used in several plants and considered in others is a pressure-sensing device and associated system to actuate automatic valves and seal the pipeline at strategic points to minimize the total spill.

c. Spill Control

In addition to the strategic location of manual or automatically actuated valves along pipelines, the most commonly accepted practice for control of spills from piping is to place a concrete or hard surface ditch under pipeline racks. The ditches normally drain rainwater to storm water disposal systems, but are usually arranged so that a spill from a pipeline, once detected, can be diverted to a chemical or oil waste disposal system or an impounding area. In locations where ditches or gutters are not suitable, graded hard surfaced areas are frequently used to direct any spilled material into chemical or storm water sewers. Many pumping areas are curbed and graded to help contain chronic leaks or spills and direct them to a waste treatment facility.

3. Loading and Unloading

Table 17 lists the principal practices used at loading and unloading areas. In addition, the following were used in one or more facilities.

- Cargo sampling before loading and unloading
- Remote pump shut down capability
- Shut off valves upstream and downstream of pumps
- Different types of couplings for different fluids
- Gravity overflow lines to sump or spare tank
- Excess flow valves (to shut off flow if limits were exceeded)
- Routine valve check before and after loading operations

Because of the apparently high potential for spills, and high spill incidence, in loading and unloading areas, the number of different techniques to prevent, detect and control spills is large. Most plant operators believe that spills are frequent during loading and unloading because:

1. Each move of liquid involves one or more temporary pipe and/or hose connections to be made.

2. This functional area is highly labor intensive, and thus very susceptible to human error.

3. Loading hoses, loading arms, and other pieces of equipment in this area are subject to severe use and therefore have a high propensity to wear and/or be damaged.

TABLE 17

SUMMARY OF SPILL PREVENTION PRACTICES USED IN LOADING AND UNLOADING AREAS

PRACTICE		NUMBER OF FACILITIES*	REMARKS
Curbing, gutters, or ditches around loading and unloading areas	Design criteria	11	System used depended on age of plant and layout of loading/unloading area
Collection sump with pump and/or oil separator in each loading/unloading area	Design criteria, Equipment	8	Used with hard surfaced, graded and curbed loading areas.
Hard surfaced loading and unloading area	Design criteria	7	
Articulated swivel joint loading arms or rigid connectors for loading	Equipment	7	Plants installing new equipment preferr this over flexible hoses
Loading areas sloped and graded toward sumps or chemical process sewers	Design criteria	6	
Standard procedures for draining fill lines (gravity drain, blow back etc.)	Procedure	6	Used primarily in terminal operations
Written procedures and check sheets for loading/unloading operations	Procedure	5	Several additional plants had written procedures for materials thought to be especially hazardous
Weighing of tank cars, trucks, or tanks with automatic shut off at preset levels	Equipment, Procedure	4	Meter loading of tank cars was practic at two other plants
Drip pans, scupper plugs, etc. used during vessel unloading and loading	Equipment, Procedure	3	Only found in oil unloading operations
Neutralization tanks locally available for spills during loading and unloading	Equipment	3	Used in facilities with acid and caustic tanks at loading sites
Company purchased booms available	Equipment	3	These were on site ready to be deployed
Level alarms on tankage used in loading and unloading	Equipment	2	
Seals on normally closed valves at loading site	Equipment, Procedure	2	
Testing and certification of hoses at scheduled intervals	Procedure	2	Mainly for large transfer hoses for oil
Clean up truck on site during loading operation	Equipment	2	Oil loading only
Gravity flow during loading and unloading	Design criteria	2	Gravity flow for first half hour or hour to check for leaks

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* Total number of facilities visited was 23

4. There is a high potential for poor communications between those on both ends of a move, for example, the terminal operators onshore and the crew on a vessel.

5. The temporary connections often are suspended directly over or close to waterways. Therefore, the difficulty in controlling a potential spill is maximized.

Our survey indicated that the more hazardous the nature of the liquid being handled at the loading and unloading facility, the more likely that various safety codes and regulations will have the indirect benefit of reducing the spill potential.

a. Spill Prevention

The most frequently used prevention measure was the increased use of articulated swivel joint arms at loading sites. Plant operators believed that the use of metal loading arms significantly reduce accidents, particularly in ship and tank car loading. At most of the facilities we visited, we were informed that new installations would use articulated arms rather than hoses.

The increased use of strict written procedures for implementing all loading practices--such as making connections, testing for leaks, using gravity flow for initial loading with the second round of leak checks, turning the loading pumps on and making a third round of leak checks, draining or blowing out the residual liquid from the loading hoses or loading arm after the liquid transfer is made, etc.--was felt to be the most important practical method of preventing spills. Examples of specific procedures are given in Appendix G.

Good communications between the shore and any ship or vessel being loaded or unloaded were thought to be critical. The persons in charge of the onshore facilities and the ship end of the transfer must be able to communicate fluently in a common language.

Automatic shutoff in loading operations were not used as frequently as we expected. Most shutoff devices consisted of an automatic shutoff valve actuated by a pre-set control meter or scale. These were used to stop loading after the tank car or tank truck had been loaded to almost maximum capacity, say 95% of the fill. The remaining 5% would be added manually. Since only a few percent of the total fill need be monitored by an operator, the attention span demanded of the operator was short and there should be less risk of an overfill.

Although not specifically expressed by many operators, we believe that preventative maintenance, inspection of hoses, valves, pumps, gaskets, etc. is an important spill prevention practice and should be placed on a more rigorous schedule.

b. Spill Detection

The principal and almost exclusive method of spill detection in loading and unloading is by visual observation of the operating personnel. Rigorous requirements for operating personnel being present during all phases of the operation is perhaps the most valid method used today for spill detection.

c. Spill Control

The most common and useful spill control measures used were curbing or ditches around loading areas and pitched, hard surfaced areas leading to sumps or chemical process drains. More than half of the plants visited used one or more of these methods. Procedures for drainage of lines or blow back into vessels also was used frequently. We found that booms were also used as a control measure; they were not typically deployed until some spill had occurred. Drip pans and other catchment devices were used to control minor leaks, but were not used as a prime preventive or control measure.

4. Process Areas

Table 18 summarizes the major practices used in process areas. Many of these are similar to those used in loading and unloading and storage areas (for example, many tanks in process areas are diked). In addition, the following practices were used in one or more facilities:

- No bottom connections on tanks
- Overflow lines to process sewers
- Cooling towers replace once through process water
- Operator on duty 24 hours/day in process area
- Total elimination of drains in process area
- Automatic level indicators in process tanks

a. Spill Prevention

In addition to the specific prevention methods listed in Table 18-- primarily level alarms, locked valves, inspection procedures, elimination of bottom connections--we found several general practices are used in the process area for purposes other than spill prevention, which plant personnel believe have an important impact on spill prevention.

1. Equipment design and specification--general adherence to established construction codes and recommended design

TABLE 18

SUMMARY OF SPILL PREVENTION PRACTICES USED IN PROCESS AREAS

PRACTICE	TYPE	NUMBER OF FACILITIES*	REMARKS
Concrete or other hard surface under process area	Design criteria	12	Recommended practice by four of five architect/engineering firms
Curbing around process areas	Design criteria	11	Recommended by all architect/engineering firms visited
Graded surfaces with ditches or chemical sewers around process areas	Design criteria	10	
Separate process and storm water sewers in process area	Design criteria	7	Spills must be directed to process sewers
Sumps or holding basins located in process areas	Design criteria	6	Fluids pumped to waste treatment area
Level or pressure alarms on process tanks	Equipment	5	Specifically used for spill prevention, not process control
Neutralization tanks at individual process sites	Design criteria	4	Found in facilities handling large quantit[illegible] of acids and alkalis
Oil skimmers or separators at process sites	Design criteria equipment	4	Remove oil before spilled fluid enters waste treatment system
Separate collection (sewer) system for especially hazardous materials	Design criteria	4	
Monitoring of process waste water for evidence of spills at process site	Equipment	4	Aids detection of spills and spill location
Procedures for directing initial rainfall in process area to waste treatment system	Procedure	3	
Scheduled inspection of all process area spill prevention measures	Procedure	3	In addition to normal preventive maintenance
Written procedures for process operation	Procedure	2	Specifically mentioned as a spill prevention measure
Sampling procedures planned to minimize spills	Procedure	2	Sampling of process streams
Locked or sealed valves in process area	Equipment	3	

* A total of 23 facilities were visited

practices to insure physical integrity of the process system has the secondary effect of preventing spills.

2. Process control procedures and equipment--use of pressure, temperature, flow, level and composition detection and control systems, planned for maintaining product quality and controlling throughput, have a secondary effect of preventing spills.

3. Operational procedures--most process operations have written or carefully planned operational procedures to maintain product quality and production rate. Such procedures can and sometimes do include spill prevention measures as a spin off.

4. Preventive maintenance--as in other plant areas, preventive maintenance to maintain production can help in elimination of potential spill causes.

b. Spill Detection

Although visual inspection for spills and leaks is the most common method of spill detection, small spills and leaks--e.g., from pump seals, valve packing, flange connections, rivets and seams easily go undetected. Plant personnel admit that appropriate action is often not taken to control these leaks. Unfortunately, this usually stems from a lackadaisical attitude on the part of operating personnel, poor housekeeping habits, and a failure to comprehend the possible catastrophic effects of even a few pounds of some hazardous polluting substances on the aquatic environment. The value of visual detection is increased greatly by a well directed and enforced spill prevention program.

Plant personnel believe that leaks and spills can also be detected by means of alarms located within the process system. The most valuable and most frequently usable in-process alarms are based on instruments that measure flow, pressure, or level of substances in the process system. Most of this instrumentation is based on measuring and controlling a dynamic system and often initiates corrective action which may control or limit the spillage. These systems are most useful in detecting the likely onset of a large-volume spill due to catastrophic accidents; however, small leaks and spills are probably not detectable or alarmable.

Alarms which are independent of the process system are utilized principally to detect materials hazardous to personnel or property such as high concentrations of hydrocarbon vapors. These detectors usually initiate a combatant action, such as foam blanketing an area where high concentrations of explosive hydrocarbons are detected, or initiating water deluges as fire protection. Such action may be useful from the personnel hazard view but incorrect from the environmental protection view.

The most common process area instrumentation for spill detection is installed in the process area's drainage systems, such as process and storm sewers. These include pH, hydrocarbon, TOC, TOD indicators. Large maintenance costs and poor reliability of these instruments are the principal reason for their present limited use.

c. Spill Control

The most commonly used methods for controlling spilled substances in process areas is the installation of graded hard surfaces, passive barriers, collecting sewers, or surface drains, which will prevent the substances from entering water courses. Installation of curbed areas around processing equipment and catch pans and basins under areas where chronic leaks are expected, e.g., under pumps, is most often practiced. Drains from the processing areas are generally segregated from storm water sewers. Catch basins or sumps are frequently located within the process area. Several plants have specific sewage systems for very hazardous materials, separate from other chemical waste and storm water. Several facility operators indicated that a more formalized spill control plan for the process area would be the most important addition to current practices.

Methods for controlling spills and leaks in a processing area depend greatly on the age of the facility. In new plants, separate process area and land drainage sewers can be readily provided and are recommended by architect/engineers. However, such provisions would be very expensive for old plants. These costs would be analogous to the costs for separating sanitary and storm water sewers in many of our older cities. Consequently, many older processing plants must consider alternate methods for the control or rapid removal of spilled substances, for example, providing secondary containment barriers near the points at which there is a high potential for spills and leaks, providing local sumps for spilled fluids, etc. An alternative is to enclose the process area while maintaining fire and safety measures.

5. Waste Treatment and Disposal

The waste treatment and disposal system of an industrial facility can be a spill prevention and control measure in itself. Although we did not examine waste treatment facilities from the view of the quality of the effluent discharge in our field survey, we attempted to obtain information on the methods by which the operation of the waste treatment system help prevent spills from entering the water environment. Table 19 summarizes the principal practices associated with waste treatment which are related to spill prevention and control. In addition, the following practices were used at one or more facilities:

- Hourly inspection of oil traps and skimmers
- Only specific employees permitted to discharge any water
- Membrane liners around holding lagoons
- Analysis of water obtained from well points surrounding holding lagoons
- Waste treatment system operator on duty 24 hours/day

All of the architect/engineers we visited recommended holding lagoons, separate sewer systems in critical areas for storm water and process waste (or spills), and effective use of a waste treatment system as a backup measure for spill prevention and control.

6. Management Practices

Our discussions with facility management and supervisory personnel during the field survey revealed several types of management practices which were believed to be major factors in the prevention and control of spills. The following practices were conducted at one or more facilities:

- Employee motivation program aimed at reduction of spills and keeping oil from entering the water
- Management emphasis on placing responsibility for spills on individual operators
- Educational program aimed at process unit operators to make them aware of the consequences of spills and that they have the ultimate responsibility for spill prevention
- Plant wide spill reporting--emergency communication system
- Formation of an independent pollution control group with broad authority
- Establishment of company wide pollution control education programs
- Specific training programs, with emphasis on pollution control, with written and oral exams to obtain operator status
- Random program of monitoring effluent and waste product streams in various parts of the process areas to alert operators to the need for control of chronic spills and leaks
- Requirement for 24 hour/day operator availability in high potential spill areas

The use, effectiveness and acceptance of these practices were influenced to a large degree by management desire to preserve water resources as well as to create an acceptable public image.

TABLE 19

WASTE TREATMENT PRACTICES WHICH AID SPILL PREVENTION

PRACTICE	TYPE	NUMBER OF FACILITIES*	REMARKS
Monitoring of waste system effluent (pH, BOD, TOD, etc) to aid in spill detection	Equipment, procedure	12	Not installed specifically for spill detection but for effluent quality
Separate sewer system for storm water and process or trade water/ waste	Design criteria	11	Must have available methods to direct spills to process waste system
Holding or diversion lagoons, ponds or tanks for large spills	Design criteria	10	Some facilities have up to five diversion lagoons; others have capability of diverting up to one week process and rainwater
Specific procedure and facilities for diverting or treating initial rainfall	Procedure, design criteria	8	May also use process and storm water sewers and diversion ponds
Single sewer system and treatment plant for all plant water--process runoff, etc.	Design criteria	4	All used water and plant effluent is handled by one system
Centrally located oil separators and skimmers in storm water and process water systems	Equipment	4	Used in plants which handle large volumes of oil
Neutralization facilities centrally located for all water systems	Design criteria	4	
Separate sewer system and waste treatment facility for very hazardous materials	Design criteria	3	Systems generally located at process areas

* A total of 23 facilities were visited

C. COMPARISON WITH OTHER SURVEYS

In order to make the results of the present survey more useful, and to include a larger and more diversified data base, we have re-examined the results of several other plant surveys made in Boston, New York, Baltimore, Charleston, W. Va., Texas City, Los Angeles, San Francisco, and Houston by our staff for the Environmental Protection Agency and others. The facilities visited, 107 in total, varied from small repackaging or formulating plants handling relatively small volumes (hundreds of gallons) to petroleum and petrochemical companies processing or storing hundreds of millions of gallons.

In summarizing observations of our survey teams, we found that a very long list of methods, equipment, and procedures would be required to describe all plants at all locations. The selection of the techniques encountered most frequently also must have a certain degree of subjectivity based on our experiences and observations. Furthermore, we could not be sure that all methods, equipment and procedures were reported to us in these visits. Nevertheless, we found the following spill prevention practices were used most frequently.

1. Diked areas around storage tanks. For flammable substances these are required; however, as a passive barrier to tank rupture, and tank and pipe connection leaks, a diked tank storage area is considered the first line barrier to containing and reducing the spread of large volume spills.

2. Tank level indicators and alarms. The sounding of alarms at prescribed levels during tank filling was expected by plant personnel to minimize the common occurrence of overflow when reliance is on manual gauging for control.

3. Above ground transfer lines. Above ground installation permits rapid detection of pipeline failures and if used with hard surfaced ditches underneath, minimizes polluting ground waters. Although increasing the possible mobility into surface waters, long term considerations are believed to favor above ground transfer lines.

4. Curbed process areas. Spills from processing equipment must often be removed rapidly from the area but should be prevented from spreading widely in the immediate area, consequently, curbed areas connected to collecting sewers are used.

5. Area catchment basins or slop tanks. For containment of small spills and leaks in the immediate area thereby effecting removal at the highest concentrations, local catchment basins can provide significant flexibility in preventing spills from entering water courses.

6. Holding lagoons for general plant area. Holding lagoons, which can be used to segregate spills and prevent them from passing into wastewater treatment plant or water courses, give the surge capabilities necessary for handling large volume or highly toxic spills.

7. Primary wastewater treatment. For removal of floating substances or for the chemical neutralization or destruction of spilled materials, the primary wastewater treatment plants serve to ameliorate the more drastic effects of spills in receiving waters.

8. Secondary wastewater treatment. The removal of soluable substances usually through biological action, where possible, can insure that the plant wastewater discharges have a high degree of uniformity at acceptable quality regardless of in-plant variations such as would occur from spills.

9 Availability of spill cleanup equipment. Vacuum trucks, booms, neutralizing chemicals, etc. represent obvious contingency planning to cope with spills.

10 Routine preventative maintenance schedules. Because literature sources and plant staff indicated that the cause of many fires and spills in the chemical industry could be traced to failures that might have been avoided by a thorough preventative maintenance program, it was recognized that this program could be an indicator of the possible reduction in spill potential.

11. Spill control plan. The formalization of a plan for coping with spills and the training of personnel in courses of action similar to plant safety programs, was reasoned to be a prime indicator of the operational possibility of coping with spills in a manner which would avoid entry into water courses.

Using the prevention factors outlined above, we have tabulated the results of 107 plant surveys. In this total number there were 31 plants which we categorized as chemical plants. The remaining 76 plants included a broad spectrum of industry except that the surveys of oil refineries were disproportionately low in comparison to the volume of fluids handled. This selection was deliberate because the petroleum industry handling operations are more closely regulated than any other industry. Three integrated oil refineries and 21 oil terminals or storage areas were surveyed. Included in our survey were facilities of industries such as pharmaceuticals, paper, steel, food, beverages, detergents, paints, waste processes, rubber, and textiles. The results of these surveys are shown in Table 20.

TABLE 20

SUMMARY OF SPILL PREVENTION AND CONTROL PRACTICES AT 107 FACILITIES

Practices	All Plants (107)		Chemical Plants (31)		This Study (23)	
	No.	Percent	No.	Percent	No.	Percent
Complete Diked Storage	47	44	13	42	12	52
Tank Farm Level Alarms	8	8	5	16	2	9
Exclusive Above Ground Transfer Lines	12	11	7	23	8	35
Curbed Process Areas	23	22	16	52	11	48
Process Area Catch Basins	14	13	5	16	6	26
Holding Lagoons	18	17	13	42	10	43
Primary Treatment	33	31	17	55	12	52
Secondary Treatment	6	6	5	16	2	9
Spill Cleanup Equipment	17	16	1	3	3	13
Preventative Maintenance Program	19	18	10	32	8	35
Spill Control Plan	42	39	19	61	14	60

We note that in general, chemical plants have a higher utilization of spill prevention and control practices than the average plant. This is probably caused by the greater number of hazardous materials handled by these plants and the inherent potential hazard to personnel and property. In the present study, about one half of the facilities visited were chemical plants. Therefore in the present survey, the utilization of practices is closer to those reported for chemical plants than for the average of all plants, of which only 29% were chemical plants.

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[9] Conservation Division, Branch of Oil and Gas Operations, Gulf Coast Region, United States Geological Survey, Outer Continental Shelf Order No. 1-10, dated August 28, 1969 and October 30, 1970.

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[12] Division of Water Pollution Control, "Rules for the Prevention and Control of Oil Pollution in the Waters of the Commonwealth", Publication No. 5131, Commonwealth of Massachusetts.

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[16] Manufacturing Chemists Association, "Case Histories of Accidents in the Chemical Industry", Volume 1, 1962, Volume 2, 1966, Volume 3, 1970.

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[23] Crocker, B. B., "Preventing Hazardous Pollution During Plant Catastrophes", Chemical Engineering, May 4, 1970, p. 97.

[24] Spill Prevention Techniques for Hazardous Polluting Substances, and Inventory and Survey of Hazardous Chemical Facilities in Charleston, West Virginia; Baltimore, Maryland; Texas City, Texas; and the Suisan Bay-Delta area, California; report prepared by Arthur D. Little, Inc., under Contract 14-12-927 for the Environmental Protection Agency, Water Quality Office, Division of Oil and Hazardous Materials, February 1971.

[25] The Prevention of Spills of Oil and Chemicals into Baltimore Harbor and Environs. Report to Maryland Environmental Service, by Arthur D. Little, Inc., May 1971.

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APPENDIX A

ASSOCIATIONS AND AGENCIES CONTACTED BY LETTER

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TABLE A-1

TECHNICAL AND TRADE ASSOCIATIONS CONTACTED BY LETTER

ASSOCIATION	REPLY RECEIVED	NO REPLY RECEIVED
AIME		X
American Association of Oil Well Drilling Contractors		X
American Foundrymens Society		X
American Iron and Steel Institute		X
American Paper Institute		X
American Petroleum Institute	X	
American Society of Civil Engineers	X	
Asphalt Institute	X	
Chemical Specialties Manufacturing Association	X	
Institute of Paper Chemistry		X
Lead Industries Association	X	
Manufacturing Chemists Association	X	
Metallurgical Society of AIME		X
National Agricultural Chemists Association	X	
National Canners Association		X
National Paint, Varnish and Lacquer Association		X
National Petroleum Refiners Association	X	
Portland Cement Association		X
Rubber Manufacturers Association		X
Synthetic Organic Chemical Manufacturers Association	X	
USA Standards Institute		X
Western Oil and Gas Association		X
Zinc Institute	X	

TABLE A-2

STATE AND MUNICIPAL AGENCIES
CONTACTED BY LETTER

	REPLY RECEIVED
ALABAMA	
Water Improvement Commission	No
Bureau of Environmental Health	No
ALASKA	
Department of Health and Welfare	Letter forwarded to Department of Environmental Conservation
Department of Environmental Conservation	Yes
ARKANSAS	
Arkansas Pollution Control Commission	Yes
State Department of Health	Yes
CALIFORNIA	
State Water Resources Control Board	Yes
Department of Public Health	Referred to Department of Conservation, Division of Oil and Gas
Fire Marshall	Letter forwarded to State Water Resources Control Board
Department of Conservation, Division of Oil and Gas	Yes
State Water Resources Control Board	Yes
COLORADO	
Colorado Department of Health	Yes
Fire Marshall	No
CONNECTICUT	
State Water Resources Commission	Yes
State Department of Health	No
Fire Marshall	No
DELAWARE	
Delaware Water and Air Resources Commission	Yes
State Board of Health	No
Department of Natural Resources and Environmental Control	Yes
FLORIDA	
Department of Air and Water Pollution	Yes
State Board of Health	Yes
Department of Natural Resources	Yes
State Fire Marshall	No
GEORGIA	
State Water Quality Control Board	No
Department of Public Health	Yes
ILLINOIS	
State Sanitary Water Board	No
Department of Public Health	Forwarded to Illinois Environmental Protection Agency
Environmental Protection Agency	Yes
Chicago Fire Department	Yes
State Fire Marshall	No

TABLE A-2 (Continued)

	REPLY RECEIVED
INDIANA	
Stream Pollution Control Board	No
State Board of Health	Yes
State Fire Marshall	Yes
KANSAS	
Kansas State Department of Health	No
Water Pollution Control Section	No
Fire Chief	No
City-County Community Health Department	No
MARYLAND	
State Department of Water Resources	Yes
Maryland State Department of Health and Mental Hygiene	Forwarded to Department of Water Resources
MICHIGAN	
Water Resources Commission	Yes
Department of Public Health	Referred to Water Resources Commission
Fire Marshall	Yes
MINNESOTA	
Minnesota Pollution Control Agency	Yes
Division of Environmental Health	No
Fire Marshall	Yes
NEBRASKA	
Nebraska Water Pollution Control Council	Referred to Department of Environmental Control
Department of Environmental Control	Yes
Fire Marshall	Yes
NEW JERSEY	
State Department of Health	No
Department of Environmental Protection Agency	Yes
Water Quality Branch, Delaware River Basin	Yes
Fire Marshall	Yes
NEW MEXICO	
New Mexico Water Quality Control Commission	No
NEW YORK	
Fire Marshall - New York City	No
Fire Marshall - Buffalo	Yes
New York Department of Environmental Conservation	Yes
Health Department	No
New York State Petroleum Council	Yes
OHIO	
Water Pollution Control Board	No
Department of Health	Yes
Fire Marshall	Yes

TABLE A-2 (Continued)

	REPLY RECEIVED
OKLAHOMA	
Department of Health	No
Department of Pollution Control	No
RHODE ISLAND	
Department of Health	Yes
Water Supply and Pollution Control	No
Fire Marshall	No
TENNESSEE	
Fire Marshall	Yes
Tennessee Stream Pollution Control Board	No
Department of Public Health	No
VIRGINIA	
State Water Control Board	Yes
Department of Health	Yes
Fire Marshall	Yes
WASHINGTON	
Fire Marshall	No
Washington Water Pollution Control Commission	Yes
Department of Health	No
WEST VIRGINIA	
Fire Marshall	Yes
Department of Health	No
Department of Natural Resources	Yes
WISCONSIN	
Department of Natural Resources	Yes
Department of Health	No

NOTE: other states--Pennsylvania, Maine, Massachusetts--were contacted by phone; written information was received.

APPENDIX B

RHODE ISLAND OIL POLLUTION CONTROL RULES AND REGULATIONS

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State of Rhode Island and Providence Plantations

OIL POLLUTION CONTROL RULES AND REGULATIONS

Effective September 1, 1957

Rhode Island Department of Health
State Office Building, Providence, R. I.
1957

Rhode Island Department of Health

RULES AND REGULATIONS

OF THE

Department of Health

To Prevent the Discharge or Escape of Any Petroleum, Gasoline, Kerosene, Tar, Asphalt, Oil, or Any Product or Mixture Thereof, into the Waters of the State of Rhode Island

1. As used in these rules and regulations the word "person" shall be held to mean and include every individual, firm, co-partnership, association, private corporation and municipal corporation, whether acting as principal, agent or servant, and whether acting personally or by agents or servants, and these rules and regulations shall apply to each and every such person.

2. As used in these rules and regulations the term "oil" shall be held to mean any petroleum, gasoline, kerosene, tar, asphalt, oil, or any product or mixture thereof.

3. As used in these rules and regulations the term "oil carrying vessel" shall be held to mean a vessel equipped to carry more than 5,000 gallons of bulk oil as cargo or as fuel for her own use.

4. No person shall discharge, or cause, suffer or procure to be discharged, or cause or suffer to escape, any liquid waste, including storm water runoff, or other waste, into any of the waters of the state from any new oil refinery, new oil storage tank farm, new industry manufacturing petroleum products, or new industry whose liquid waste or storm water runoff or other waste may contain oil, placed into operation after these rules and regulations are established by order, unless plans and specifications and a description of a system or means to be installed to prevent the escape of oil which may be present in such liquid waste, storm water runoff or other waste have been submitted to the Department of Health, and an order of approval of the same has been entered by said department.

5. No person shall discharge, or cause, suffer or procure to be discharged, or cause or suffer to escape, any oil into any of the waters of the state; provided however that this rule shall not apply to any waste waters passed through any oil separating or treatment equipment approved by the Department of Health, and operated in a manner acceptable to said department and in conformance with any standards of operation contained in said department's order of approval.

6. No person shall deposit, or cause, suffer or procure to be deposited, any oil in any place on the bank or shore of any of the waters

of the state or on any wharf or pier in any such waters, where the same shall be likely to be washed into any of the waters of the state either by heavy rains, high tides, or storms, except hurricanes, or in any place where the same shall be likely to be discharged or to escape into any of said waters.

7. No person shall pump or discharge, or cause, suffer or procure to be pumped or discharged into any harbor, river, bay, inland waters or any of the waters of the state, bilge or ballast water from any oil carrying vessel or from any other ship, barge, tanker, boat or vessel whereby any oil shall be liable to be discharged or to escape into any of the waters of the state.

8. No person shall scrape, wash, scrub, scour or swab, or cause, suffer or procure to be scraped, washed, scrubbed, scoured or swabbed, any part of any ship, barge, tanker, boat or vessel, or any tank or receptacle thereon, while such ship, barge, tanker, boat or vessel is in any harbor, river, bay, or other waters of the state or on any shore thereof or in any dry dock within the state, or any oil tank or oil receptacle in any place, whereby any oil shall be liable to be discharged or to escape into any of the waters of the state.

9. No person shall transfer, or cause, suffer or procure to be transferred, any bulk oil from any oil carrying vessel to shore, or from shore to any oil carrying vessel, or ballast or cause, suffer or procure to be ballasted any oil carrying vessel unless the scuppers of any such vessel are plugged watertight during the oil transfer or ballasting operation.

10. No person shall transfer, or cause, suffer or procure to be transferred any bulk oil from any oil carrying vessel to shore or from shore to any oil carrying vessel unless the following precautionary measures against oil spillage into the waters of the state during the transfer have been taken:

a) Any flexible hose used in the transfer which has not been in regular use shall have been tested at a pressure in excess of that to which it will be subjected in use, and such test shall be made within one month previous to such use.

b) Drip pans are placed under hose connections on the oil carrying vessel, and drip pans or a tight wharf or pier section enclosed by a curb raised to not less than four inches above the deck level is provided under the hose connections on the wharf or pier. If drip pans are used they must be in place before tight blank, as provided in f) of this rule, is removed and they must remain in place until blank is replaced and hose is moved. This rule shall not prevent the instalation of a drain to a tight curbed wharf or pier section for the removal of storm water, provided the drain is tightly closed during any oil transfer and no oil contaminated drainage from the tight section is discharged into the waters of the state, when the drain is open.

c) Hoses are supported so as not to become crushed between the ship and the wharf or pier.

d) Hoses are long enough so that they will not be strained by any movement of the ship if the ship's mooring lines are adequately tended.

e) Mooring lines are tended frequently to prevent excessive movement of the ship at the wharf or pier.

f) Hose ends are blanked tightly when hoses are moved into position to be connected, and also immediately after they are disconnected, before they are moved away from their connections.

11. No person shall transfer, or cause, suffer or procure to be transferred bulk oil from any oil carrying vessel to shore or from shore to any oil carrying vessel unless a man is stationed on the deck of such vessel in sight of the hose and its vessel connections, and another man stationed on shore in sight of the hose and its shore connections continuously during the transfer; provided, however that in the case of the transfer of oil to or from an oil barge, one man stationed where he can have a clear view of both the deck and the dock will suffice.

12. No person shall transfer, or cause, suffer or procure to be transferred bulk oil from any oil carrying vessel to shore or from shore to any oil carrying vessel after sunset and before sunrise unless decks and the wharf or pier area at the point of transfer are brightly illuminated during the transfer.

13. No person shall transfer, or cause, suffer or procure to be transferred any bulk oil from any oil carrying vessel to shore unless:

a) All cargo risers not intended for use in the transfer are blanked.

b) Sea valves connected to the cargo piping, and stern loading connections are tightly closed and sealed with a numbered seal.

c) Lines and valves in the pumprooms and on deck are checked by the ship's master or senior deck officer to see that they are properly set for discharging cargo. An additional check is made for the same purpose each time the setting is changed.

d) Means of communication with shore facilities are checked and thoroughly understood.

e) Discharging is started slowly until shore lines are proven clear.

f) A check valve to prevent backflow is located in the discharge line of each oil cargo pump of a centrifugal type; the check valve shall be located at a point in the discharge line ahead of any connection the line makes with the discharge line from any other cargo pump on the vessel.

g) A copy of the "Declaration of Inspection" required by the United States Coast Guard has been handed to the terminal superintendent or his representative, who shall on demand be given the opportunity to satisfy himself that the condition of the vessel is as stated in the "Declaration of Inspection."

14. No person shall transfer, or cause, suffer or procure to be transferred any bulk oil from shore to any oil carrying vessel unless:

a) All sea valves connected to the cargo piping, stern discharge, and ballast discharge valves are closed and sealed with a numbered seal.

b) All hose riser valves not to be used are closed and blank flanged, and all air valves on headers are closed.

c) Means of communication between ship and shore are ascertained and all signals between ship and shore thoroughly understood.

d) Loading is started at a slow rate and an inspection made of the ship's tanks to determine that all is going according to plan before loading is increased to desired rate.

e) No more tanks are loaded at one time than can be safely watched and controlled.

f) Special attention is paid during the topping-off process to the loading rate, the number of tanks open, the danger of air pockets and the inspection of tanks already loading.

g) To allow time for orderly control, the slow down for topping-off is anticipated and notice given to shore personnel.

h) Water around the ship's side is inspected frequently, especially in the way of the seacocks, to insure that no oil is escaping overboard.

i) Upon completion of loading, all tank valves and loading valves are closed. After draining, hoses are disconnected and hose risers blanked.

15. No person shall ballast, or cause, suffer or procure to be ballasted any oil carrying vessel unless:

a) The transfer of cargo has been completed and all hose riser valves have been closed and connections blanked.

b) If ballast is to be pumped in, whether through deck lines or bottom line; valves on the lines used are set first, then the valves to the tanks to be ballasted are opened, the necessary valves in the pumprooms, except seacocks, are set next, and cargo pumps are started before opening seacocks.

c) If ballasting is done by gravity, ballast is pumped in first for ten minutes in accordance with the procedure outlined above in b) to clear all bottom lines of oil.

d) When ballasting is started, all tanks are inspected to see that only the tanks intended are receiving ballast.

e) The same attention is given to ballasting as to topping-off tanks when loading cargo.

f) When completing the loading of ballast, seacocks are closed before stopping the pumps.

The provisions of a), b), c), f) of this rule shall not apply to any vessel whose ballast piping system and ballast pumps are wholly independent and not connected to the cargo system.

16. No person shall discharge, suffer or procure to be discharged, the exhaust steam from any coil or other device used to heat oil, into the water of the state or into any public sewer or storm drain, or into any private drain which empties into any of the waters of the state or onto the banks of any of these waters unless such exhaust steam is first passed through an oil removal system approved by the Department of Health.

17. No person shall discharge the drainage from any underground pipe gallery used as a conduit for oil pipes, or the drainage from the floor of any boiler room where oil burning equipment is located, into a public sewer or storm drain or into the waters of the state or onto the banks of these waters without first passing the drainage through an oil removal sysem approved by the Department of Health. This rule shall apply only to the drainage from business and industrial establishments.

18. No person maintaining a dike around an oil storage tank shall have any openings in such dike that will permit the escape of drainage from behind the dike into any sewer or drain or into the waters of the state.

An opening such as a pipe provides, may be placed in the dike provided it is kept closed at all times except for periods, no longer than are necessary, to remove accumulated drainage. When it is necessary to remove such drainage it shall be passed thru an oil removal system approved by the Department of Health, unless it is wholly oil free. If free of oil it may be discharged as desired. If temporary openings in the dike are made to permit doing work on or inside the same, provision must be made while the openings exist to convey drainage from the dike to an oil removal system approved by the Department of Health, or other provision made to prevent such drainage from reaching the waters of the state without the removal of any oil it may contain.

19. Every person operating a terminal for the transfer of oil from ship to shore or from shore to ship shall, when a spillage of oil occurs at his terminal, take steps immediately to contain the spilled oil, and remove it from the water if any has reached it. For this purpose he shall have readily available adequate essential equipment approved by the Department of Health and personnel familiar with such salvage operations.

20. Every person operating a terminal for the transfer of oil from ship to shore or from shore to ship shall inspect every ship using his ter-

minal and fill out the inspection report supplied to him by the Department of Health, and submit the same to said department promptly when the ship has left the terminal.

21. Every person who handles oil shall, when a spillage of oil occurs on his premises, take steps as promptly as possible to prevent the spilled oil from reaching a public sewer or drain or in any way any of the waters of the state.

22. No person shall discharge the drainage from any bulk oil plant yard, refinery area, or other outdoor area where large volumes of oil (more than 21,000 gallons) are received or stored or shipped, and where by accident or otherwise oil may escape or be spilled into any public sewer or drain or into any of the waters of the state, without first passing such drainage through an oil removal system approved by the Department of Health. This rule shall not prevent the discharge into any public sewer or drain or into the waters of the state of any oil free drainage from such areas if means are provided to retain the drainage for inspection befort it is discharged and only oil free drainage is so discharged.

23. No person shall maintain a vent to any oil storage tank located on the premises of a business or industrial establishment that is filled through an opening in the top of the tank except one carried at least three feet higher than the opening, in order that the oil will first overflow at the inlet to the tank if the tank is filled beyond its capacity. This rule shall not apply to a tank used to store only fuel oil of a grade which will flow at all times without being heated.

24. No person shall maintain an inlet to an oil storage tank located on the premises of a business or industrial establishment except one so located or protected that should the tank overflow accidentally on filling, the oil will be retained near the tank and will not reach any public sewer or drain or the waters of the state. This rule shall not apply to a tank used to store only fuel oil which will flow at all times without being heated.

25. No person shall permit any oil pipe to leak oil in any location where the oil may be washed or drained into a storm drain or sewer or into the waters of the state.

26. Every person shall post and keep posted such warning signs or copies of extracts of these rules and regulations as may be provided to him by the Department of Health, in a conspicuous place where the same may be easily read, at each of the wharves and piers owned, leased, operated or controlled by such person, and at each separate parcel of land owned or leased by such person which borders on, or any part of which is within one hundred feet of any of the waters within the state, and whereon there is deposited or stored at any one time, any oil, in greater quantity than twenty-one thousand gallons.

27. These rules and regulations shall be in full force and effect on and after the first day of September A.D. 1957 and any previously issued orders establishing rules and regulations to prevent the discharge of oil into the waters of the state are hereby declared to be null and void, on and after that date.

Ordered on the twelfth day of August A.D. 1957.

Violations of an order of the Department of Health are punishable by a fine of not more than five hundred dollars ($500.00) or by imprisonment for not more than one (1) year, or by both such fine and imprisonment. (Section 14, Chapter 12, Title 46, General Laws of 1956).

APPENDIX C

SELECTIONS FROM "RULES FOR THE PREVENTION AND CONTROL OF OIL POLLUTION IN THE WATERS OF THE COMMONWEALTH OF MASSACHUSETTS"

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Section 4.0--MARINE OIL TERMINAL TRANSFER OPERATIONS

Particular care is essential to prevent oil pollution cause by spills during transfer of bulk oil from a vessel to shore, or from shore to a vessel or during ballasting.

Section 4.01--PRE-TRANSFER CONFERENCE

Prior to commencing oil transfer operations, the following items shall be understood and agreed by both vessel and shore personnel in responsible charge of operations:

a. Cargo sequence for loading or discharging products.

b. Handling rate at which oil will be transferred. Reduced rates are required when commencing ransfer, changing the lineup, topping off tanks, or nearing completion of transfer. The amount of standby time to be given when the vessel or terminal desires to start, stop, or change the rate of flow must be agreed upon.

c. Adequate communication and signal systems must be established and checked, and must be readily available during transfer operations.

d. Emergency procedures to be followed in order to stop and contain any spillage must be understood.

Section 4.02--VESSEL OPERATIONS

During oil transfer operations, the following procedures shall be followed by vessel personnel:

a. A licensed officer or certified tanker-man who has full knowledge of the vessel's tanks and cargo handling system shall be in charge of cargo handling.

b. A sufficient number of adequately-trained men shall be on duty during cargo operations.

c. The vessel shall be moored with adequate lines to prevent surging, and the mooring lines shall be properly tended to prevent the lines from either parting or developing excess slack.

d. All scuppers shall be plugged during transfer operations. If scuppers must be unplugged to drain water from the deck area, they shall be tended constantly and the plugs replaced immediately. No oil or emulsion shall be discharged through scuppers.

e. The ends of hoses or other connecting devices shall be blanked while being put in place. A drip-pan shall be used at the cargo or bunker manifold when removing the blank and making up the connection. The drip-pan shall be left in place during transfer operations. Connections shall be secured to insure against leakage. Flanges, joints and hoses shall be checked visually for cracks, weak spots or points of excessive stress.

f. Before commencing transfer operations, the initial lineup shall be checked from the deck manifold connection through the system to the first tank valve to see that valves are properly set. All valves which are not involved in initial transfer operations must be closed tightly. Sea-valves connected to cargo or bunker piping systems, stern discharge and ballast discharge valves shall be closed and sealed during transfer operation.

g. During transfer operations, a man or men shall be stationed where vessel connections, hose and terminal connections can be observed. Regular inspections shall be made of the transfer lineup, of water around the vessel, and of connections and other points subject to leakage.

h. On completion of transfer operations, hoses or other connecting devices shall be vented, blown down, or sucked out to drain the remaining oil. A drip-pan shall be used when breaking a connection, and the end of the hose or other connecting devices shall be blanked off before being moved.

i. During ballasting, pumps shall be started before opening sea-valves, and pumps shall be stopped after closing sea-valves.

Section 4.03--TERMINAL OPERATIONS

a. Procedures outlined in Section 4.02 for vessel operations also apply to terminal operations where appropriate.

b. A tight wharf or pier section enclosed by a curb is satisfactory in place of drip-pans, provided no oil-contaminated drainage is discharged into the waters of the Commonwealth.

c. Before commencing discharge of dirty ballast or slop-oil to terminal facilities, the system and lineup shall be checked. During transfer the system shall be checked regularly for leakage.

d. Where waste oil collection and separation facilities are installed, the separator shall be checked regularly for proper operation.

e. Care shall be taken to prevent leakage or spillage of oil from drip-pans when they are dumped for disposal.

f. Terminal operators shall have a maintenance inspection and testing program for all oil-handling hoses and equipment in order to detect faulty equipment.

Section 4.04--USE AND CARE OF HOSE

a. Any hose used in oil transfer service shall be of a grade suitable for oil service and be designed to withstand pressure of the shut-off head of the pump or pump relief valve setting. Such hose shall be tested annually at a pressure in excess of that to which it is subjected in use.

b. Hoses shall be supported during transfer operations so as not to be crushed between the vessel and wharf or to be subjected to strain due to excessive curvature.

c. Hose lines shall be sufficiently long and adequately supported so as not to be strained excessively by any movement of the ship due to tides or change in draft during oil transfer operations.

d. Hoses shall not be permitted to chafe on the dock or ship, or to be in contact with hot surfaces such as steam pipes, or to be exposed to other corrosive sources.

Section 5.0--TERMINALS, BULK PLANTS & OTHER INSTALLATIONS HANDLING OIL

5.01 All terminals and bulk plants shall be so located and constructed as to provide against flooding by high water and the accidental discharge of oil to water courses.

5.02 Proper maintenance measures shall be provided and due caution exercised to prevent any spills or discharges of oil to water courses.

5.03 Any drainage which may contain oil in such amounts as to cause, or contribute to, a condition in contravention of the established water quality standards must first be passed through a properly maintained and adequate oil-trap or other oil removal system approved by the Division.

This shall include, but not be limited to:

a. Surface drainage from any oil-contaminated area of a terminal, bulk oil plant yard or other outdoor area where large volumes of bulk oil are received or stored, or shipped.

b. Drainage from any pipe trench or pipe gallery used as a conduit for oil pipes.

c. Exhaust steam, condensate or water from any device used to heat or cool oil.

5.04 Each permanent oil storage tank or battery of tanks must be surrounded by a dike or retaining wall of sufficient capacity to contain spillage and prevent pollution of the surrounding areas. Accumulated drainage shall be removed through a properly maintained and adequate oil-trap or other oil removal system approved by the Division.

APPENDIX D

SELECTED REGULATIONS OF THE TEXAS RAILROAD COMMISSION

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RULE 8. WATER PROTECTION

(A) Fresh Water to be Protected

Fresh water, whether above or below the surface, shall be protected from pollution whether in drilling, plugging, producing, or disposing of salt water already produced.

(B) Exploratory Wells

Any oil or gas well or well drilled for exploratory purposes shall be governed by the provisions of statewide or field rules which are applicable and pertain to the drilling, safety, casing, production, abandoning and plugging of wells, and all operations in connection therewith shall be carried on so that no pollution of any stream or water course of this State, or any subsurface waters, will occur as the result of the escape or release or injection of oil, gas, salt water or other mineralized waters from any well.

(As added by Order No. 20-56,841, effective 1-1-69).

(C) (1) All operators conducting oil and gas development and production operations are prohibited from using salt water disposal pits for storage and evaporation of oil field brines and mineralized waters.

(a) The provisions of this rule do not affect the use of burning pits which are used exclusively for the burning of tank bottom waste accumulation.

(b) Impervious collecting pits may be approved for use in conjunction with approved salt water disposal operations, provided that authority must be received for use of such pits from the Commission.

(c) Discharge of oil field brines and mineralized waters into a surface drainage water course, whether it be a dry creek, a flowing creek or a river, except where permitted by the Commission, is not an acceptable disposal operation and is prohibited.

(d) Disposition of oil field brines and mineralized waters through off-lease facilities where transportation is by tank trucks, pipelines or other means, is the initial responsibility of the lease operator and shall not be initiated until such method of disposition is permitted by the Railroad Commission. Such permit shall be subject to review and cancellation should investigation show that the permitted method of disposition is abused.

(2) Exceptions to the provisions of this rule may be granted by the Railroad Commission on special request where good and sufficient cause is shown.

(3) Penalty for non-compliance with any part of this rule shall be pipeline severance for each lease operated in violation of this rule.

(4) In any instance where a salt water disposal pit is presently in use and is abandoned, due to cessation of flow of salt water thereto, whether voluntary or mandatory, such pit shall be backfilled and compacted.

(D) Pollution Prevention

(As added by Order No. 20-59,200, effective 5-1-69)

(1) The operator shall not pollute the waters of the Texas offshore and adjacent estuarine zones (salt water bearing bays, inlets, and estuaries) or damage the aquatic life therein.

(2) All oil and gas well drilling and producing operations shall be conducted in such a manner to preclude the pollution of the waters of the Texas offshore and adjacent estuarine zones. Particularly, the following procedures shall be utilized to prevent pollution.

(a) The disposal of liquid waste material into the Texas offshore and adjacent estuarine zones shall be limited to salt water and other materials which have been treated, when necessary, for the removal of constituents which may be harmful to aquatic life or injurious to life or property.

(b) No oil orother hydrocarbons in any form or combination with other materials or constituent shall be disposed of into the Texas offshore and adjacent estuarine zones.

(c) All deck areas on drilling platforms, barges, workover unit and associated equipment both floating and stationary subject to contamination shall be either curbed and connected by drain to a collecting tank, sump or enclosed drilling slot in which the containment will be treated and disposed of without causing hazard or pollution; or else drip pans, or their equivalent, shall be placed under any equipment which might reasonably be considered a source from which pollutants may escape into surrounding water. These drip pans must be piped to collecting tanks, sumps or enclosed drilling slots designed to accommodate all reasonably expected drainage. Satisfactory means must be provided to empty the sumps or enclosed drilling slots to prevent overflow or prevent pollution of the surrounding water.

(d) Solid combustible waste may be burned and the ashes may be disposed of into Texas offshore and adjacent estuarine zones.

Solid wastes such as cans, bottles, or any form of trash must be transported to shore in appropriate containers. Edible garbage, which may be consumed by aquatic life without harm, may be disposed of into Texas offshore and adjacent estuarine zones.

(e) Drilling muds which contain oil shall be transported to shore or a designated area for disposal. Only oil-free cuttings and fluids from mud systems may be disposed of into Texas offshore and adjacent estuarine zones at or near the surface.

(f) Fluids produced from offshore wells shall be mechanically contained in adequately pressure-controlled piping or vessels from producing well to disposition point. Oil and water separation facilities at offshore and onshore locations shall contain safeguards to prevent emission of pollutants to the Texas offshore and adjacent estuarine zones prior to proper treatment.

(g) All deck areas on producing platforms subject to contamination shall be either curbed and connected by drain to a collecting tank or sump in which the containment will be treated and disposed of without causing hazard or pollution, or else drip pans, or their equivalent, shall be placed under any equipment which might reasonably be considered a source from which pollutants may escape into surrounding water. These drip pans must be piped to collecting tanks or sumps designed to accommodate all reasonably expected drainage. Satisfactory means must be provided to empty the sumps to prevent overflow.

(h) Any person observing water pollution shall report such sighting, noting size, material, location and current conditions to the ranking operating personnel. Immediate action or notification shall be made to eliminate further pollution. The operator shall then transmit the report to the appropriate Commission district office.

(i) Immediate corrective action shall be taken in all cases where pollution has occurred. An operator responsible for the pollution, shall remove immediately such oil, oil field waste, or other pollution materials from the waters and the shore line where it is found. Such removal operations will be at the expense of the responsible operator.

(3) The Commission may suspend producing and/or drilling operations from any facility when it appears that the provisions of this rule are being violated.

(4) (As added by Order No. 20-60,214, effective 10-1-70)

The foregoing provisions of Rule 8(D) shall also be required and enforced as to all oil and gas operations conducted on the inland and fresh waters of the State of Texas, such as lakes, rivers, and streams.

APPENDIX E

SURVEY GUIDE

SURVEY GUIDE

A. STORAGE, TRANSFER, LOADING AND UNLOADING

These facilities are intended to include tank farms for raw and refined products from which transfers are made for transportation to non-contiguous areas for use or further processing. In the case of petroleum products or certain other hazardous, combustible products, a number of legal requirements exist as to the location of tanks within diked areas of defined configurations. However, many tank farms for hazardous polluting substances do not now have such protection against movement of spilled liquids and the interviewer should consider questions of the following type:

(a) What are typical fail-safe procedures and equipment employed for filling and emptying storage tanks, e.g., are the pumps equipped for automatic shutdown on high-level indication in a tank being filled; are lines entering the tanks located so that siphoning effects are prevented in the case of line breakage; in the case of long lines of large diameter, what provisions are made for liquids draining out in case of rupture, etc.?

(b) In diked storage tank areas, how is rainfall runoff handled, i.e., is there an installed drainage system which is provided with normally shut valves; is ground seepage adequate to remove rainfall--if so, what about ground water pollution? Does the rainfall go to a holding basin or through a wastewater treatment plant before it can enter water courses?

(c) Are tanks equipped with remote level sensing and alarming systems sounding into a central location?

(d) What administrative procedures are in effect concerning notification of spills?

(e) Are there any unique regulations based on experience or safety requirements that dictate certain design procedures, for example, the generation of electrostatic charges by discharging the entering liquid above the surface of the liquid in the tank?

(f) What design standards are presently used for the transportation equipment of concern, i.e., are these standards developed by an industry group, promulgated by insurance companies, defined by the carriers, or established by the equipment owners?

(g) Are operators of transportation equipment familiar with the type of cargo, methods for controlling and combating spills, and/or know how and where to seek rapid assistance in the case of an accidental spill? For example, is the MCA's Chem-Card Manual utilized?

(h) Since an accidental spill of a hazardous polluting substance is most often best combated by containment in a localized area followed by removal for disposal, what types of equipment are carried for effecting such an operation? For example, a tank truck operator might be expected to have available shovels for creating small dikes to prevent rapid migration into water courses.

(i) What fire, explosion and personnel safety requirements are now demanded by regulatory groups and how do these requirements affect the prevention or detection of spills and leaks?

B. PROCESSING PLANTS

Questions should be based on the fail-safe concepts of operation and hardware that are presently installed to meet (1) personnel safety regulations, (2) preventing loss of valuable materials, (3) fire insurance or other codes, and (4) protection of equipment. Interviewers should be especially alert to in-plant procedures for coping with spills especially to such operations as water flushing for safety or removal reasons and what procedures are utilized to prevent spilled hazardous polluting substances (HPS) from entering surface and ground waters.

(a) What fail-safe procedures are incorporated in the process designs and operational procedures? For example, are pressure, temperature, liquid level, and flow rate sensors alarmed? Do these sensors actuate the closing of valves, the shutdown of pumps, or a fire protection system? Are there any special fail-safe procedures required for insurance regulations or by legal or other codes?

(b) Are process areas curbed on a selective basis, i.e., with respect to the volume and specific degree of hazard involved in the material handled?

(c) How is the drainage from the plant and the process areas handled? For example, are there separate sewer systems from process pads going to special waste-water treatment facilities? If curbed areas are unable to contain the maximum credible spill, i.e., the maximum volume present in the processing units located in the area, where would the overflow go, i.e., into storm sewers draining directly to water courses, to holding basins, to municipal sewers, and so on?

(d) Where holding basins (used for surge capacity) are installed so that runoff or overflows can be treated prior to discharge to water courses, what is the design basis? For example, the maximum 24, 48, etc., hour rainfall over a 10, 20, 50 year or other period?

(e) Before a holding or catchment basin is emptied, what decisions are made as to whether the contents are emptied through treatment plants, or directly into receiving waters? What analytical procedures are carried out?

(f) Are special handling equipment, or treating agents, e.g., lime for acid neutralization, located throughout the plant for cleanup of spilled substances?

(g) Is there any special, non-process, detection instrumentation now installed that has a sole function of alarming if spills occur? What type of detection equipment is now installed for safety reasons and what is the nature of any process controls actuated by this equipment?

(h) What degree of reliability is placed upon present detection and alarm sensors, especially with respect to experience and the backup or spare philosophies incorporated in design and operation.

(i) What has been the major attributable causes for past in-plant spills regardless of size or whether these entered receiving waters, for example, process equipment failure, operator error, control equipment failure and so on.

APPENDIX F

DETAILED RESULTS OF FIELD SURVEY

DESIGN CRITERIA, EQUIPMENT, AND PROCEDURES IN CHEMICAL FACILITY - PLANT A

ITEM	TYPE	AREA
1. Drainage ditches surrounding acid tanks lead to neutralization area	Design criteria, equipment	Storage
2. Spare acid tanks for rapid transfer in case of leaks in primary tanks	Equipment	Storage
3. Scheduled manual gauging of all storage tanks once per shift	Procedure	Storage
4. Tanks diked to prevent spills from entering waterway	Design criteria, equipment	Storage
5. Reduce number of flanges in piping systems to reduce leaks	Design criteria	Transfer
6. Pipelines located overhead (above grade) to help locate leaks	Design criteria	Transfer
7. Metal articulated swivel joint loading arms for liquid transfer to rail and tank cars	Equipment	Loading and unloading
8. Concrete gutters (curbing) along rail and truck unloading areas to convey spills to neutralization or treatment area	Equipment, design criteria	Loading and unloading, waste treatment
9. Gravel covered loading and unloading points to prevent runoff	Design criteria	Loading and unloading
10. Concrete surfaced pad surrounded by curbing and/or drainage ditch in process area	Design criteria, equipment	Process
11. Large centrally located lime slurry tank for neutralization	Equipment	Process, loading and unloading
12. Common neutralization facility in addition to principal waste treatment facility	Equipment	Waste disposal
13. Continuous pH monitoring to detect spills or leaks in main waste treatment stream	Equipment and procedures	Waste disposal
14. Discharge to county waste treatment facility on a fee basis	...	Waste disposal

Principal Hazardous Materials

Inorganic acids; chlorinated rubbers and waxes, ammonia, chlorine, alcohols, toluene, wax, chlorinated hydrocarbons

PLANT A (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Neutralization area required	
	For acid tanks only
Sight tubes and float gauges used also	
Fail-safe system for dike valves required	Acid tanks diked; alcohol tanks diked to prevent loss of costly fluid
	Efforts made in all new lines to weld joints because of leaky flanges
Continuous inspection required to identify leaks	
	Experience indicates loading arms are more reliable than flexible hoses
Adequate neutralization area required	Mostly used for acid areas and spills
	May actually be detrimental since acids can enter ground water; curbing may be better
Adequate neutralization or holding area required	
Distribution method for slurry and disposal of material required	
	Prevents overloading of waste treatment facility in case of spills
Neutralization facility and equipment required	
	This is a back-up system for waste treatment facilities; is used when overloaded

DESIGN CRITERIA, EQUIPMENT, AND PROCEDURES IN CHEMICAL FACILITY - PLANT B

ITEM	TYPE	AREA
1. Storage tanks of hazardous materials are diked	Design criteria, equipment	Storage
2. Tanks containing hazardous materials have no bottom connections; fluids pumped from top	Design criteria, equipment	Storage, process
3. Storage tanks have high level alarms and "high-high" levels shutoff for pumps	Equipment	Storage, process
4. Overflow lines from tanks run to process area ditch	Equipment	Storage, process
5. Major valves may be locked to prevent unauthorized use	Procedure	Storage, process
6. Special toxic materials stored in underground concrete tanks with impervious membrane layer in tank walls	Design criteria, equipment	Process, storage
7. Flange bonnets used on mechanical pipe connections	Equipment	Transfer
8. Closed sections of lines protected with relief valves and burst disks	Equipment	Transfer
9. Written procedures for all operations from transfer to processing; sign-off sheets checked step by step by operator, filed for record	Procedure	Storage, transfer process
10. Materials are sampled and analyzed for compatability before transfer operations	Procedure	Storage, transfer
11. Manual (stick level) gauging done periodically to check instrumentation	Procedure	Storage, transfer
12. Written permission of supervisor required to override safety shut-off system	Procedure	Storage, transfer process
13. Different type (design) couplings for different substances	Design criteria, equipment	Transfer, loading and unloading
14. Transfer areas sloped and graded toward process drains	Design criteria	Transfer, loading and unloading
15. Rail transfer areas curbed, with sump for spills; liquid must be pumped from sump	Design criteria, equipment	Loading and unloading
16. Process areas sloped toward process area ditches and drains	Design criteria	Process
17. Rainwater ditches separate from process drain; used to drain swampy areas direct to river	Design criteria	Process, other

PLANT B (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	There are no penetrations in dikes; fluids are pumped out if contained in diked area
	Prevents leakage from valves by gravity flow
Alarms and indicators are located in central control room, manned continuously	
	This is a back-up system to convey overflows to holding areas.
	Has both advantages and disadvantages as a fail-safe system
	Prevents toxic material from entering ground water
	Prevents leaks in and damage to flange joints
System for collection or drainage of any vented materials required	
	Supplements fail-safe equipment and design criteria; helps operator reduce possibility of accidents
	Prevents chemical reactions--primarily a safety procedure which can act as a pollution control measure
	Check on fail-safe instrumentation
	Prevents accidental flows of materials to wrong lines or tanks--mainly a safety feature
Adequate process waste treatment required	
Sumps must be large enough to handle maximum spill	Used only for most hazardous or toxic materials
Process drain system required	
Method to ensure that spills cannot get into rainwater ditches required	

DESIGN CRITERIA, EQUIPMENT, AND PROCEDURES IN CHEMICAL FACILITY - PLANT B (Continued)

ITEM	TYPE	AREA
18. Process areas hard surfaced	Design criteria	Process
19. Fire control deluge water flows into process area ditch	Design criteria	Process
20. Separate holding basins in each process area	Equipment, design criteria	Process
21. Holding basin with 24-hour capacity	Equipment	Waste treatment
22. Double capacity emergency basin	Equipment, design criteria	Waste treatment
23. pH monitors at inlets to each basin	Equipment	Process, waste treatment
24. pH instruments checked three times daily by grab samples and lab analysis	Procedure	Waste treatment
25. Visual checks periodically for oil downstream of skimmers	Procedure	Waste treatment
26. Heavy metal and other pollutants monitored	Procedure	Waste treatment
27. Settling basins have membrane liner to prevent seepage	Equipment	Waste treatment
28. Well points surround settling basins sampled to check for leakage	Procedure	Waste treatment

Principal Hazardous Materials

Chlorinated hydrocarbons, inorganic acids, caustic, oil, metal alkyls, acetone, kerosene

PLANT B (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Some process storage tanks with volatiles on gravel
Fire control deluge water may contain hazardous materials and requires treatment	
	Each process area has holding basin of capacity equal to all tanks and equipment in area
	This is a back-up for holding tanks in process areas
	This is a back-up for large spills; fluids must be diverted to basin
	Used to activate caustic addition system to neutralize waste streams
	This is a back-up measure to ensure automated equipment works well
	Check on equipment
	Used to check if spill has occurred or as process control
	Back-up system to detect faulty operation

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN OIL STORAGE AND TERMINAL FACILITY* - PLANT C

ITEM	TYPE	AREA
1. All storage tanks for oil and hydrocarbons are diked	Design criteria, equipment	Storage, process
2. Process sewer system for drainage of fluids in diked areas	Equipment	Storage
3. Leak detection system for pipelines--consisting of flow meters and meter provers, with computer system to check input and output	Equipment	Transfer
4. Separate sumps provided at blending, packaging, and loading facilities	Design criteria, equipment	Loading and unloading
5. Standard procedures for draining flexible hoses after loading by gravity for barge operations	Procedure	Loading and unloading
6. Standard procedures for pumping to drain flexible hose lines on tanker operations	Procedure	Loading and unloading
7. Temporary mounted high level alarms in barges to provide visual and audio alarm on filling	Equipment	Loading and unloading
8. All process units on hard surface pads	Design criteria	Processing
9. Standard procedure for flushing and draining sample lines into process waste sewer	Procedure	Processing
10. Once through cooling water visually inspected and instrumented for measurement of total organic carbon before discharge back to river	Procedure, equipment	Processing
11. Waste water effluent from solvent recovery and other process units monitored for dissolved carbon	Procedure, equipment	Process, waste treatment
12. Imponding area for rainwater to handle 24-hour drainage from worst storm in seven-year period	Equipment	Waste treatment
13. Most of area served by two waste systems, one for only water, the other clean	Equipment, design criteria	Waste treatment
14. Chemical waste water kept separate from oily waste water	Design criteria	Waste treatment
15. Turbidity monitor for water leaving oil/water separator	Equipment	Waste treatment

Principal Hazardous Materials

Fuel and lubricating oils, asphalt, oil additives, inorganic acid and caustic

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*Old refinery used as storage and distribution facility primarily

PLANT C (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Fire regulations require diked storage
Valving or pumping system required to make this fail-safe	
	Present system is inadequate and must be replaced. Approach is thought to be valuable if system accuracy can be improved. Probably detects large leaks.
Disposal system required	
	Is fail-safe only to extent used by operators.
	In experimental stage, believed to give tanker personnel false sense of security--not connected to shut-off system
Curbing and drainage system required	
	Prevents release of product to waterway
	Detects leaks in heat exchangers; requires diversion system and catch basins in event of accident
	Detects leaks but not fail-safe
	Not fail-safe, but prevents most accidents in plant discharge from reaching waterway
	Allow two levels of treatment and different separation and treatment techniques
	Detects overloading of separator and prevents direct release of oil into clean waste treatment facility

DESIGN CRITERIA, EQUIPMENT, AND PROCEDURES USED IN PLASTICS AND RUBBER FACILITY - PLANT D

	ITEM	TYPE	AREA
1.	Dikes around individual tanks or groups of tanks	Design criteria, equipment	Process, storage
2.	Separator pits for draining tanks	Design criteria, equipment	Process
3.	First half hour of heavy rain runoff flows into trade waste system for processing in water treatment area	Procedure	Process, storage
4.	Lagoon for diversion of one day's trade waste for further processing	Design criteria	Waste treatment
5.	Other lagoons for diversion and storage of 2-3 days' waste	Design criteria	Waste treatment
6.	Sight glasses on tanks	Equipment	Process
7.	Written handling procedures for loading and unloading tanks	Procedure	Storage, process loading and unloading
8.	Level or pressure alarms on critical tanks	Equipment	Transfer, process
9.	Piping above ground with concrete ditches underneath	Design criteria, equipment	Transfer
10.	Operator on duty in waste treatment area 24 hours a day	Procedure	Waste treatment
11.	Concrete ditches surrounding tank car unloading area	Design criteria,	Loading and unloading
12.	Hard surfaced areas near loading and facilities	Design criteria	Loading and unloading
13.	Gravity overflow lines on tanks	Design criteria, equipment	Loading and unloading, process

Principal Hazardous Materials: Butadiene, Styrene, Latex, Rubber Formulations.

PLANT D (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Requires control of valves and lines going through dikes	
Requires system for disposal of material collected in pits	Used whenever tanks are being cleaned or as an overflow protection measure
Requires separate storm and process waste system	Used to collect any oil or wastes that would be washed off in heavy rain; one half hour may be insufficient
	Used when load on waste processing is heavy or failure in system
This is a back-up for waste treatment system	
Requires operator's use	
	Not fail safe, but may help to prevent spills
Requires appropriate maintenance and checking	
	Ditches empty into trade waste, and are used to collect any spills from pipes
	Operator is able to divert flows or spills
Requires adequate waste treatment or disposal system	
Requires collection system as described above	
Requires sumps or holding vessels for overflow	Overfilled tanks release material by gravity flow to sump or tank instead of spillage

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN PETROCHEMICAL AND CHEMICAL FACILITY - PLANT E

	ITEM	TYPE	AREA
1.	Dikes around most storage tanks	Design criteria, equipment	Process, storage
2.	Sumps or traps with eductors inside diked area	Design criteria, equipment	Storage
3.	Excess flow valves on critical lines used during transfer	Equipment	Loading and unloading
4.	At least one catch basin or holding tank in each process waste stream	Design criteria, equipment	Process, waste treatment
5.	Skimmers in storm sewer runoff stream	Equipment	Waste treatment
6.	Concrete barrier around hazardous materials tanks	Design criteria, equipment	Process, storage
7.	Sumps with eductors in concrete barrier tanks	Equipment	Process, storage
8.	Level alarms on selected tanks	Equipment	Process
9.	Operator in control room 24 hours per day	Procedure	Process
10.	Feed line pumps of critical materials can be shutoff by scales under tank cards or process vessels	Equipment	Process, loading and unloading
11.	Separators, sumps, and process sewers used to collect spills in loading areas	Design criteria, equipment	Process, loading and unloading
12.	Return lines on loading of cars goes to separate tank	Design criteria, equipment	Loading and unloading
13.	Planned inspection of hoses and piping	Procedure	Storage, transfer
14.	Rigid connections on materials of high hazard	Equipment	Loading and unloading

PLANT E (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Sumps or valves in lines passing through dikes required	
This is a back-up system for dikes	Spills in diked areas cannot flow out under gravity
	If flow is too large due to tank or line failure, flow is shutoff
Requires operators to observe use of system	A safety measure to prevent heavy loading of waste treatment system
	Planned to remove any hydrocarbons from runoff water
	Used primarily as a safety measure around very flammable and hazardous materials
Is a back-up system to prevent gravity flow of spilled materials	
	Used mostly for flammable or hazardous materials
Back-up for alarm system	
	Used primarily in transfer of very hazardous materials to prevent overfilling
Is a back-up system for transfer of fluids	
Is a back-up system during filling operations	Gravity flow [illegible] to sumps [illegible] tanks
	Normal plant practice with extra attention given to hazardous materials lines
	Eliminates problems of flexible lines

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN PETROCHEMICAL AND CHEMICAL FACILITY

PLANT E (Continued)

ITEM	TYPE	AREA
15. Use of atmospheric pressure and vacuum systems to convey materials rather than pumps	Design criteria, equipment	Loading and unloading
16. Curbing around selected process areas	Design criteria	Process

Principal Hazardous Materials: Chlorine, Alcohols, Olefins, Sodium, Flammable Materials.

PLANT E (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Believed to reduce potential for spills during transfer operations
Is a back-up system for small spills in process area	

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN REFINERY AND STORAGE AND DISTRIBUTION FACILITY

PLANT F

	ITEM	TYPE	AREA
1.	Separate storm water and process water systems	Design criteria, equipment	Process
2.	Four large guard basins to retain storm water	Design criteria, equipment	Waste treatment
3.	Dikes around selected tanks	Design criteria, equipment	Storage
4.	Separate drainage system for diked tanks	Design criteria, equipment	Storage
5	Emphasis on placing responsibility for spills on operator	Procedure	
6.	Cathodic protection of pipelines, frequent corrosion inspection	Design criteria, procedure	Transfer
7.	Testing and certification of hoses at loading dock on regular basis	Procedure	Loading and unloading
8.	Use of articulated swivel joint steel loading arms on increasing level	Equipment	Loading and unloading
9.	Gravity flow of oil for first half hour to check connections before applying pump pressure	Procedure	Loading and unloading
10.	Low pressure shutoff on selected lines	Equipment	Transfer
11.	Drip pans at appropriate loading points	Equipment	Loading and unloading
12.	Securing of normally closed lines (valves) by seals	Procedure	Process, loading and unloading, storage
13.	Small local tanks of acid or caustic to help in neutralization	Equipment, design criteria	Process, waste treatment

PLANT F (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Design to separate oily wastes from water runoff
Must have method to divert flow into these basins	Designed for holding storm water or spills for further treatment
	Dikes used depending upon flammability of material
This is a back-up system to separate material released in diked areas	
	This is an attempt to make employees more aware of the control and consequences of spills
	Plant staff believe these are safer than flexible hoses
Requires manual check for leaks, drip pans, etc.	Used to help spot leaks when under low pressure and prevent large leaks
	Used to detect if there is a leak in pipeline
	This is planned to eliminate accidental opening of drain lines, dike feed throughs, etc. which could result in spills
Need curbs or dikes around tanks	Used to help neutralize on site small spills

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN REFINERY AND STORAGE AND DISTRIBUTION FACILITY

PLANT F (Continued)

ITEM	TYPE	AREA
14. Continuous monitoring of waste water system for pH at several points	Equipment	Waste treatment
15. Hard surfaces in process areas	Design criteria	Process
16. Above grade product lines over drainage ditches	Design criteria	Process, transfer
17. Gauging manifolds on tanks	Equipment	Storage, loading and unloading

Principal Hazardous Materials: Oil, Hydrocarbons.

PLANT F (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Requires system for monitoring of other substances as well	
	Drainage goes to waste treatment system
	Permits rapid measurement of tank levels during transfer operations

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN PETROCHEMICAL AND CHEMICAL FACILITY - PLANT G

ITEMS	TYPE
1. Separate chemical sewer and clean water storm sewer drainage systems.	Design criteria
2. Rainwater collection and holding pond to contain first fifteen minutes of runoff; the remainder being diverted directly into waterway.	Design criteria, procedure
3 Practically all piping is above ground.	Design criteria
4. Regular periodic inspection using standard procedures for all piping including hydrostatic testing and visual inspection.	Procedure
5. Normal activities of plant operation requires operators to observe or at least walk along some of the exposed pipelines during their daily activities.	Procedure
6. Long interfacility liquid transfer pipelines supplied with check valves, and emergency liquid storage tanks at both ends.	Design criteria, equipment
7. Standard procedures established for communicating via telephone between both ends of long major interfacility pipelines.	Procedure

PLANT G (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process, other	Backup system to insure chemical spills do not get into the rainwater discharge from the facilities.	
Process, other	Requires means for detection of chemicals or contaminants in rainwater runoff diverted directly to waterway.	Collects the potentially dirty initial rainwater runoff which has washed old spills of chemicals from processing areas, etc.
Process, other		Permits immediate visual detection of leaks or spills associated with transfer pipelines.
Transfer, other		Primary purpose is to prevent accidents--built-in spill prevention and detection aspects.
Transfer, others		Certain sample points or data taking points are stratically located in plant, such that operators must regularly visi these points--requiring their visual observation of pipelines and other equipment enroute.
Transfer		In case of emergency, the entire contents of the transfer pipeline can be emptied into a storage tank at either end of the pipeline.
Transfer	This is a backup system for the preceding item.	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN PETROCHEMICAL AND CHEMICAL FACILITY - PLANT G (Continued)

ITEMS	TYPE
8. All moves of liquid through large major intercompany transfer pipelines made in increments or "batches", utilizing transfer tanks located at both ends of pipeline.	Procedure, equipment
9. Areas under transfer pipelines have concrete surface.	Design criteria
10. Loading racks at loading terminal are mounted over concrete surface.	Design criteria
11. Education program aimed at process unit operators to make them aware that they have the ultimate responsibility for spills.	Procedure
12. Sample lines purged into collection drums.	Procedure
13. LPG storage tanks equipped with high-pressure alarms.	Equipment, design criteria
14. LPG pumps equipped with high-flow cutoff.	Design criteria, equipment
15. Many storage tanks are surrounded by dikes.	Design criteria, equipment

PLANT G (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Transfer	Requires gauging of liquid levels in receiving tanks and transfer tanks.	Close control provided over quantities moved, with inventory control providing direct indication of spills.
Transfer, processing	Grade, curbing, and drainage system required.	
Loading and unloading.	Curbing, grade, and drainage system required.	Any liquids lost in this area of high-spill potential and frequency are directed to containment rather than being allowed to escape.
Process, others	Records maintained by company for each employee, showing record of spills caused by each employee; poor record can result in official reprimand, time off without pay, or loss of job.	This philosophy gives promise of being an ultimate "fail-safe" procedure for preventin spills.
Process	Collections and disposal of liquids from purged waste liquid collection drums.	This replaces the old system of purging sample lines simply onto the ground or processing pad.
Storage	Requires attention of operator, and subsequent appropriate corrective action.	
Storage, transfer		
Storage	Requires proper dike drainage system operation to insure impounding of spills, and the proper transfer to waste disposal of the contained spill.	Dikes are required by fire regulations, but also serve as an effective "fail-safe" spill prevention measure.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN PETROCHEMICAL AND CHEMICAL FACILITY

PLANT G (Continued)

ITEMS	TYPE
16. Some storage tanks are equipped with high-level alarms.	Design criteria, equipment
17. Manual tank gauging occurs regularly.	Procedure
18. A log is maintained which indicates the condition (open or closed) of each valve on the drain lines from dikes surrounding storage tanks.	Procedure
19. Large impounding area provided for holding of any large spills of chemicals which would drain from the plant at a rate higher than the maximum which the waste treatement facilities could handle.	Design criteria
20. Process areas handling the most hazardous materials from a pollution viewpoint are completely surrounded by dikes, drainage ditches, etc. and are provided with specific waste treatment facilities designed specifically for those materials being handled.	Design criteria
21. Loading arms are washed with a minimum quantity of solvent which is collected in containers designated for used solvent for collection and disposal.	Procedure, equipment

PLANT G (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage		
Storage	Manual gauging provides a back-up for the tanks with continuously monitored liquid level indicators	
Storage		This procedure was developed to provide better control over the position of drain valves from dikes which should be in the normally closed position such that any spill will be impounded behind the dike. and can later be drained under control to waste treatment or product recovery areas.
Waste treatment	This is a backup system for the main waste treatment facilities	After a large spill was collected and impounded, it could be fed back to the waste treatment facility at a rate that would not exceed the waste treatment facility's capacity during normal plant operation
Process	The main waste treatment facilities of the plant provide backup for the specialized waste treatment facilities serving the hazardous process area	An example of such a system is one in which phenol is processed.
Loading and unloading	Regular collection of waste solvent and transportation to waste disposal facilities required	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN PETROCHEMICAL AND CHEMICAL FACILITY - PLANT G (Continued)

ITEMS	TYPE
22. All sewers sampled at least once a day. Chromotography used to identify each specific chemical in the sewer system.	Procedure
23. Suction trucks are used to remove waste chemicals collected in sumps during equipment "turn-around".	Procedure, equipment

Principal Hazardous Materials: Chlorine, Organic Solvents, Phenol

PLANT G (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process, other	**This is a backup system for the various monitoring and detection procedures and systems used to identify spills in processing storage and other areas.**	The presence of any organic products in excess of the acceptable limits set by the company is traced to the specific operator responsible.
Processing, other	Regular chemical sewer system and waste treatment facilities.	Waste materials from equipment cleaning operations are removed in a concentrated form, thereby facilitating disposal.

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES IN REFINERY, OIL STORAGE, AND DISTRIBUTION FACILITY

PLANT H

	ITEM	TYPE	AREA
1.	Drainage Ditches or Dikes around entire plant site	Design Criteria, Equipment	all
2.	Storage tank diked--diked to 125% of capacity	Design Criteria	Storage
3.	Drainage from diked areas, process, and plant go to retention basins	Design Criteria, Procedure	all
4.	Wastewater treatment plant for all water streams leaving plant	Design Criteria, Equipment, Procedure	Waste Disposal
5	Retention basins		
	(a) Normal	Design Criteria,	all
	(b) Excess	Procedure	all
6.	Loading areas drain to wastewater treatment plant	Design Criteria, Procedure	Loading
7	Company owned boom for barge loading area	Procedure	Loading
8.	Curbed process areas	Design Criteria	Process
9.	Articulated Loading Arms	Equipment	Loading
10.	Process piping on racks	Design Criteria	Process, Transfer, Loading
11.	Standby Wastewater Transfer Pumps	Design Criteria, Equipment	Waste Disposal
12.	Development of plant water recycle system	Procedure	all

Principal Hazardous Materials:

Petroleum Products from Crude Through Refined Acids, Phenols, Heavy Metals

PLANT H (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
All drainage leads to holding basins	Serves to insure that internal plant spillages are not removed beyond property line
Holding basins and plant perimeter dikes & ditches used	Dikeage required for safety reasons
Plant perimeter dikes and ditches used	Requires all water to go through wastewater treatment plant
Retention basins required	Plant employs physical and chemical separation processes for removal of pollutants
Excess basins & perimeter dikes and ditches used	Holds normal run-off and surges
Perimeter dikes & ditches used	Diked area around two tanks is used to receive excess storm drainage via pumping
Retention basins required	Meets plant operational philosophy of treating all water emissions regardless of source
	Part of industry-government group under National Contingency Plan
Drains to wastewater treatment plant required	Normal design criteria to prevent spreading and to direct flow to treatment facility
Drainage to wastewater treatment plant required	
Drainage systems	Ease of leak detection, repair, renovation
	Since all water streams leaving plant area must be pumped, good operational practices dictates spares
	To minimize overall water usage and improve efficiency of usage

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES IN METAL PRODUCTS FACILITY - PLANT I

	ITEM	TYPE	AREA
1.	Elimination of drains in areas handling highly toxic chemicals	Design Criteria, Procedure	Process
2.	Batch collection and treatment of all water streams	Design Criteria, Procedure	All
3	In old plants, sealing of all area drainage sewers	Procedure	All
4.	Diking of tanks	Design Criteria	Storage
5.	Discharge of treated wastewater to municipal sewers	Procedure	Waste Disposal
6.	Designation of specific employees to discharge treated waters	Procedure	Waste Disposal
7.	Roofing of areas where spills might occur	Design Criteria	Transfer, Loading & Unloading
8.	Waste sludge disposal by regulatory agency approved contractors	Procedure	Waste Disposal
9.	Company program for education of operating personnel	Procedure	General

Principal Hazardous Materials: Paints, Solvents, Cyanides, Heavy Meals, Oils.

PLANT I (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Manual removal and disposal required	Most positive method for containment and treatment
	Small volume of wastewater streams permits collection & treatment to degree required for emission
Wastewater treatment system required	Only practical method to insure collection
Wastewater treatment system required	Done on a selective basis--prefer to depend upon drainage & collection to central water treatment system
	Company policy to treat to level acceptable to municipal sewage system in order to insure that additional treatment is given before emission
	Assigns responsibility for insuring that quality of treated wastewaters meets established standards
Wastewater treatment system required	Objective is to insure that storm water drainage does not remove spilled substances since it is more economical to provide roofing than large wastewater treatment plant capable of handling storm water flows
Regulatory agency approval	Company will not contract with unlicensed disposers because of contingency liability possibilities
	Company believes that operating personnel must be made aware of the consequences of leaks and spills

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES IN CHEMICAL FACILITY - PLANT J

	ITEM	TYPE	AREA
1.	Large number of separated process units	Design Criteria, Procedure	
2.	Prohibition of certain processing operations at plant	Procedure	
3.	Extensive sewer system equipped with automatic recording instrumentation	Design Criteria, Procedure	all
4.	Diked tanks	Design Criteria	Storage
5.	Holding basins and lagoons	Design Criteria, Procedure	Waste Disposal
6.	Primary and secondary wastewater treatment plant	Design Criteria, Procedure	Waste Disposal
7.	Random program of monitoring the effluents from individual process areas	Procedure	All
8.	Curbed process areas	Design Criteria	Process

PLANT J (Continued)

REQUIRED OR USED BACK-UP SYSTEM	REMARKS
	Segregation permits greater attention to problems peculiar to a particular process.
	The hazardousness of certain products is regarded as so great that incorporation of adequate safeguards at this location is infeasible.
Wastewater treatment plant required.	Selected points in process sewer system are analyzed on short-time repetitive schedule for carbon containing or oxygen demanding substances. Results are electronically recorded in central control. System provides alarms and causes actions to be initiated.
Collection system and wastewater treatment plants required	Dikes are provided on a selective basis. However, because of plant experience wherein a tank rupture washed out a dike, plant relies on area ditches, & peripheral dikes to prevent spread beyond plant borders.
Wastewater treatment plant	Large volume basins are maintained into which "slugs" of spilled substances can be routed for purposes of dilution and for protection of biological wastewater treatment plant.
	Plant can be operated in many different modes, is equipped with monitoring & control instrumentation, operated by trained personnel, & protected against upsets by the use of holding basins & lagoons to which slugs of hazardous polluting substances can be sent.
	A highly visual sampling station installed on a random schedule on sewers from processing areas results in encouraging operating personnel to improve housekeeping, reduce leaks, and decrease load to wastewater treatment plant since they know that record is being obtained.
Wastewater treatment plant required	Good operating procedures to confine leaks and spills to desired channels.

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES IN CHEMICAL FACILITY - PLANT J (Continued)

ITEM	TYPE	AREA
9. Plant wide spill reporting system	Procedure	All
10. Independent Pollution Control Group	Procedure	General
11. Plant safety--Pollution Control Educational Program	Procedure	General

Principal Hazardous Materials: Large Variety of Reactive Organic and Inorganic Chemicals

PLANT J (Continued)

REQUIRED OR USED BACK-UP SYSTEM	REMARKS
Flexible wastewater treatment system required.	Special telephone and alarm system is available for reporting spills and leaks. Employees are trained in its use & are subject to disciplinary action for failure to report unless protection of life & property takes precedence. Through the establishment of a pollution control group reporting to top management, area management can be judged on the effectiveness of pollution control efforts. Group has authority to require periodic reviews of water usage & reviews all changes & additions in processing sites. Plant management has established a direct correlation between safety record and pollution control record for operational areas. Consequently, education and training of plant personnel in both areas is carried on continuously. Furthermore, records show that wastewater plant pollution load is decreasing even though overall plant production is increasing.

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN REFINERY, STORAGE AND DISTRIBUTION FACILITY PLANT K

ITEM	TYPE	AREA
1. Plant graded toward drain system	Design criteria	Process
2. Waste process system separate from water runoff system	Design criteria	Process, storage, loading and unloading
3. Overflow and emergency basins for holding heavy rain and emergency spills	Design criteria	Waste treatment
4. Scheduled startup, maintenance and shutdown of storage and process areas done with area drains blocked	Procedure	Storage, process
5. Planned inspection and replacement of pipelines, equipment, etc.	Procedure	Storage, process transfer
6. Specific trainee programs with oral and written exams for operator status	Procedure	Process, loading and unloading
7. Check sheets used for many transfer and process operations	Procedure	Process, loading and unloading
8. Daily check of pipelines from wharf to plant	Procedure	Transfer
9. Selected storage within concrete diked area	Design criteria	Storage
10. Oil spill booms available on dock	Equipment	Loading and unloading
11. Low dikes used in storage areas when more than one tank within a common dike	Design criteria	Storage
12. Rainwater accumulated and drained sequentially from diked areas using manually actuated valves	Design criteria, procedure	Storage
13. Automatic level measurement systems widely used	Equipment	Process, storage
14. Trailer loading facility graded toward hold tank	Design criteria	Loading and unloading

PLANT K (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Adequate waste treatment system required	
	Separate treatment of selected streams before combining process wastes
This is a back-up system for all spills	Five-day total retention based on worst 30-year rainfall is provided
Requires checklist to insure drains unblocked at end	Plant experience indicates spills occur during startup, maintenance and shutdown. This helps contain spills during these times
	Specified replacement dates and X-ray, dye technique inspection provided
Requires controlled use of check sheets	This is an attempt to get operators more responsible for spills
	Tanks very near water course are diked by concrete barriers
Requires proper use of booms	Not fail safe but a control measure
	Used to contain limited spills and rainwater
	Prevents overloading water treatment system; manual valves normally closed
	Central control stations with operators can monitor tank levels regularly

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN REFINERY, STORAGE AND DISTRIBUTION FACILITY

PLANT K (Continued)

ITEM	TYPE	AREA
15. "Meter Loading" of trucks with calibrated meters	Procedure	Loading and unloading

Principal Hazardous Materials: Oil, Hydrocarbons.

PLANT K (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Helps to prevent spill by transferring limited amounts

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN CHEMICAL FACILITY - PLANT L

	ITEM	TYPE	AREA
1.	Acid and caustic tanks and loading areas have individual catch basins to hold stored capacity	Design criteria, equipment	Storage
2.	All oil process areas have sewer system leading to trap and skimmer	Design criteria, equipment	Process
3.	Double capacity trap for oil operations	Design criteria, equipment	Process
4.	Cooling towers replacing once through process water	Design criteria, equipment	Process
5.	Paved process areas to control runoff	Design criteria	Process
6.	Hourly visual inspection of oil collection trap	Procedure	Waste treatment
7.	High level alarms on indoor tanks	Equipment	Process, storage
8.	Overflow lines on outdoor storage tanks	Design criteria, equipment	Process, storage
9.	Oil tanks within common dike; acid and caustic tanks have separate dikes	Design criteria	Storage, process
10.	Dikes drained by pump out rather than gravity	Design criteria	Storage, process
11.	Rail tracks and truck loading areas sloped toward drain system	Design criteria	Loading and unloading
12.	Tank car valves routinely checked before and after loading and unloading	Procedure	Loading and unloading
13.	Specific procedures for transfer operations with check lists	Procedure	Process loading and unloading

Principal Hazardous Materials: Oil Detergents, Soaps.

PLANT L (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Requires some separation and treatment of process water	Frequent spills occurred from leaks into process water and into water course
Waste water collection and treatment required	
	Inspection performed so that diversion can be accomplished
	Primarily a safety measure
Requires drainage system for overflow	
	Primarily due to plant siting requirements
This is a back-up system for spills into dikes	
Adequate drain system required	
	Plant staff feels that this is most important in preventing spills

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED IN METAL PRODUCTS FACILITY - PLANT M

	ITEM	TYPE	AREA
1.	Separate sewer system for waste acid	Design criteria	Process, waste treatment
2.	Neutralization or removal (by hauling) for acid streams	Design criteria, procedure	Process, waste treatment
3.	Oily waste separated in API separators and trucked away	Equipment, procedure	Process
4.	Oil skimmers on all main plant water ditches	Equipment	Waste treatment
5.	Acid tanks placed in concrete dammed area with drain to acid sewer	Design criteria	Process, waste treatment
6.	Gravity loading of acid trucks	Design criteria, procedure	Process, storage
7.	Hard surface truck loading acid area	Design criteria	Process, loading and unloading
8.	High level alarm in sump used in acid storage area	Equipment	Process, storage
9.	Automatic pH control of effluent	Equipment	Waste treatment

Principal Hazardous Materials: Acid, Caustic, Oil and Oily Waste.

PLANT M (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Metal acid wastes are trucked away; relatively clean acids are neutralized
Requires adequate waste oil separation system	
Same as above	
	Designed to prevent spills during pumping operations
This is a back-up measure to detect unusual acid leaks	
	Required because of acid content of waste streams

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT USED IN STORAGE AND DISTRIBUTION FACILITY

PLANT N

	ITEM	TYPE	AREA
1.	All tanks within common dike	Design criteria, equipment	Storage
2.	Shutoff valves up and downstream of pumps	Design criteria, equipment	Storage, loading and unloading
3.	Sampling of all cargoes prior to unloading	Procedure	Loading and unloading
4.	Blow back of flexible hoses to ship	Procedure	Loading and unloading
5.	Hard surface transfer areas	Design criteria	Transfer, loading and unloading
6.	Blending and canning operations inside diked area	Design criteria	Process
7.	Dip stick gauging is standard	Procedure	Storage, loading and unloading
8.	Drainage valves on dikes	Design criteria	Storage

Principal Hazardous Materials: Xylene, Toluene, Glycol, Agricultural and Organic Chemicals.

PLANT N (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Small facility with tanks next to each other
	Helps prevent spills at pumps--a frequent occurrence
This is a back-up system to prevent accidents.	Also used to maintain product quality
	Prevent spills during disconnecting lines
	Spills are common in blending operations but are small
	Poor experience with level gauges suggests this approach is better

DESIGN CRITERIA, PROCEDURES, AND EQUIPMENT USED IN REFINERY, STORAGE, AND PETROCHEMICAL FACILITY - PLANT O

ITEM	TYPE	AREA
1. Process areas are sloped toward plant ditch system	Design criteria	Process
2. Separate collection system for phenols, sulfides, ammonia, etc.	Design criteria, equipment	Process, waste treatment
3. Oily waste streams flow into closed drain system to central oil-water separator	Design criteria, equipment	Process, waste treatment
4. Clean process water and treated water go to large holding basins	Design criteria	Waste treatment
5. Petroleum tanks diked with concrete dikes in process area and earthen dikes elsewhere	Design criteria	Storage and process
6. Water drains in dikes open only during rain periods and checked every two hours	Design criteria, procedure	Storage
7. Elevated transfer piping with regular inspection procedures	Design criteria, procedure	Transfer
8. Overpressure relief valves on transfer lines	Equipment	Transfer
9. Automatic shutoff valve system with liquid level gauges	Design criteria, equipment	Transfer, storage, loading and unloading
10. Transfer areas for truck and rail loading sloped toward drains	Design criteria	Loading and unloading
11. Tank car wash water goes through oil separator	Equipment	Loading and unloading
12. Scupper plugs on tankers and barges	Equipment	Loading and unloading
13. Flexible hoses being replaced by metal loading arms	Equipment	Loading and unloading
14. Catch basins used on ships under connections	Equipment	Loading and unloading
15. Lines either drained back to ship or pumped out before disconnect	Procedure	Loading and unloading

PLANT O (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	This is a reclamation system which acts to prevent discharge of these materials
This is a back-up system for all spilled materials.	Three to five week holdup times in large basins
	Diking due to local fire codes
Careful checking required to make fail safe.	
Requires method of collection of vented substances.	
	System now being installed based upon good experience at other locations
	Better experience obtained with metal system
	Procedure depends upon elevation of ship and wharf

PLANT O (Continued)

ITEM	TYPE	AREA
16. Written instruction to ship personnel before unloading	Procedure	Loading and unloading
17. Written procedures and check sheets used for all transfer operations	Procedure	Loading and unloading
18. Cleanup truck on standby during repair operations	Procedure, equipment	Process, loading and unloading
19. Employee motivation program aimed at reducing spills and keeping oil from water	Procedure	

Principal Hazardous Materials: Oil, Phenol, Acid, Caustic, Petroleum Products and Derivatives.

PLANT O (Continued)

REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
	Language problems have resulted in past spills
Not fail safe, but a backup for other equipment	
	Believe that employee training and motivation is essential to prevention program

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN METAL PRODUCTS FACILITY - PLANT P

ITEMS	TYPE
1. Many storage tanks surrounded by dikes	Design criteria, equipment
2. Manual tank gauging occurs regularly.	Procedure
3. All underground fuel storage tanks are equipped with mechanical-type internal liquid level sensing devices with above-ground visual indicators.	Design criteria, equipment
4. The ground covering all of the buried storage tanks is graded such than any spills above ground will be directed into the waste water treating system.	Design criteria
5. A single sewer system handles all rain-water runoff as well as any spills of liquids from the processing, manufacturing operations, or storage tank farm areas.	Design criteria, equipment
6. All areas in which solvents, cutting oils, and acids are used are provided with appropriately sloping hard surfaced floors, and curbing, which will direct any spill to a sump from which it is pumped either into a storage tank for reprocessing, or disposal.	Design criteria

Principal Hazardous Materials: Oil, Acid Washes, Metal Treatment Chemicals.

PLANT P (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage	Requires proper dike drainage system operation to insure impounding of spills, and the proper transfer to waste disposal of the contained spill	Dikes are required by fire regulations
Storage	Manual gauging provides a back-up for the tanks with continuously monitored liquid level indicators	
Storage	Operator must take effective action	
Storage	Appropriate sewer system and waste water treating system required	Only those leaks which occur above ground can be handled by this approach.
Processing, transfer, others		Although such a system maximizes the waste treatment facilities necessary, it insures treatment of all liquids leaving the plant facilities.
Process, other	Regular collection of waste solvent, acid, etc. and transportation to waste disposal facilities required	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN OIL TERMINAL AND OIL REFINERY

STORAGE AND DISTRIBUTION FACILITY - PLANT Q

ITEMS	TYPE
1. Each tank of any barge operating within the metropolitan district near this facility requires the use of a high-level alarm.	Equipment
2. Standard procedures regularly used to pressure test each flexible hose against a blind flange bolted on the hose end.	Procedure
3. Flexible loading hoses preferred over swivel-jointed, articulated loading arms.	Equipment
4. After a loading or unloading operation has been completed at a marine terminal, the hoses are drained by gravity either into the vessel or back into the shore-mounted storage tank (depending upon relative elevations).	Procedure
4. All storage tanks are equipped with level indicators which register on a tank-side gauge.	Equipment
5. Manual tank gauging occurs regularly.	Procedure

PLANT Q (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Loading	Appropriate action on the part of a licensed tanker man present on the barge during loading operations	A high-level alarm in the strict sense is not a fail-safe device. and proper functioning of such a device tends to make operating personnel put absolute reliance on the continued perfect functioning of the equipment, which in itself can be responsible for major spills in the event of equipment failure
Loading		Leaks from flexible pressure hoses due to damage incurred during handling, or deterioration resulting from their normally exposed locations dictates strict testing procedures.
Loading		Each swivel-joint viewed as a point of vulnerability with regard to leaks. Experience has shown that flexible hoses give better, and more leak-fr service than swivel-jointed a at marine terminals.
Loading and unloading		
Storage	Gauging of liquid levels in all tanks by manual means.	
Storage	Manual gauging provides a backup for the tanks with continuously monitored liquid level indicators.	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN OIL TERMINAL AND OIL REFINERY, STORAGE AND DISTRIBUTION FACILITY - PLANT Q (Continued)

ITEM	TYPE
6. A single sewer treatment conveys all rainwater runoff and any oil spills to the waste water treatment system.	Design criteria
7. All marine terminals are equipped with an oil-water separator.	Design criteria, equipment
8. Practically all piping is above ground.	Design criteria
9. Regular periodic inspection using standard procedures for all piping including hydrostatic testing and visual inspection.	Procedure
10. Normal activities of plant operation requires operators to observe or at least walk along some of the exposed pipelines during their daily activities.	Procedure

Principal Hazardous Materials: Oils, Hydrocarbons, Organic Products.

PLANT Q (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage, others		Although this approach minimizes the risk of untreated spills leaving the facility proper (if designed well) it maximizes the size of waste water treatment facilities required.
Storage, others	Waste water treatment system following oil-water separator used	An oil-water separator serves the dual purpose of recovering valuable petroleum products which are spilled and carried from the facilities with rain-water or deluged flushing systems required by various insurance and fire codes. and also serves to minimize the treatment load placed on the waste water treatment facilities by a large spill of oil or other petroleum products.
Process, other		Permits immediate visual detection of leaks or spills associated with transfer pipelines.
Transfer, other		Primary purpose is to prevent accidents--built-in spill prevention and detection aspects.
Transfer, other		Certain sample points or data taking points are stratically located in plant, such that operators must regularly visit these points--requiring their visual observation of pipeline and other equipment enroute.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN OIL REFINERY, STORAGE, AND PETROCHEMICAL FACILITY - PLANT R

ITEM	TYPE
1. Separate chemical sewer and clean water storm sewer drainage systems.	Design criteria
2. Essentially all piping is above ground	Design criteria
3. Regular periodic inspection using standard procedures for all piping, including hydrostatic testing and visual inspection.	Procedure
4. Areas under transfer pipelines have concrete surface.	Design criteria
5. Suction trucks are used to remove waste chemicals collected in sumps during equipment "turn-around".	Procedure, equipment
6. During loading or unloading operations between a tanker and the terminal, the scupper plugs must be closed in order to contain any oil spill to the deck of the vessel.	Procedure
7. Some storage tanks are equipped with high-level alarms.	Design criteria, equipment
8. Many storage tanks are surrounded by dikes.	Design criteria, equipment
9. Manual tank gauging occurs regularly.	Procedure

PLANT R (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process, other		Insures chemical spills do not get into the rainwater discharge from the facilities.
Process, other		Permits immediate visual detection of leaks or spills associated with transfer pipelines.
Transfer, other		Primary purpose is to prevent accidents--built-in spill prevention and detection aspects.
Transfer, processing	Grade, curbing, and drainage system required.	
Processing, other	Regular chemical sewer system and waste treatment facilities used.	Waste materials from equipment cleaning operations are removed in a concentrated form, thereby facilitating disposal.
Loading and Unloading	Means for removing oil-contained on deck required.	
Storage	Operator required to take effective action	
Storage	Requires proper dike drainage system operation to insure impounding of spills, and the proper transfer to waste disposal of the contained spill.	Dikes are required by fire regulations, but also serve as an effective "fail-safe" spill prevention measure.
Storage	Manual gauging provides a backup for the tanks with continuously monitored liquid level indicators.	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN OIL REFINERY, STORAGE, AND PETROCHEMICAL FACILITY -

PLANT R (Continued)

ITEMS	TYPE
10. Computer control capability for monitoring and controlling all of the liquid moves associated with the storage tanks terminals, and pipelines.	Design criteria
11. The sludge which is removed from the bottom of storage tanks during their periodic cleaning is performed on a contract basis and is removed by the waste disposal contractor.	Procedure
12 Samples of waste water moving through the sewer systems and the waste disposal facilities are regularly monitored for pH, Toc, and oil content.	Procedure
13. All surge tanks are located at the offsites with the final product storage tanks.	Design criteria
14. Standard procedures established for communicating between ship and shore during loading and unloading operations at the marine terminal	Procedure

Principal Hazardous Materials: Oils, Hydrocarbons, Organic Products.

PLANT R (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage, other		This system is presently in the early stages of evolution, but the intent is clearly to provide a computerized system to handle the logistics of the movement and storage of liquid in a complex refinery/terminal operation. from which close inventory control and leak detection should be resulting by-products.
Storage		Industry appears to be turning to this solution for the disposal of materials which are difficult to treat.
Process, Other	Diversion or other facilities to hold fluids outside normal tolerances required	
Storage, Other		Any over filling of surge tanks due to problems or error in operation in the processing areas will result in spills which can contained and handle by the facilities which exist for this purpose at the storag areas.
Loading and unloading		Communications between ship an shore during unloading of larg oceangoing tankers at marine terminals can be a significant problem with the relatively small crews extant on todays large supertankers. and the language barriers which often exist when large tankers are manned by non-English speaking crews.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN CHEMICAL FACILITY - PLANT S

ITEMS	TYPE
1. Only storage tanks containing flammable liquids are surrounded by dikes.	Design criteria, equipment
2. A single sewer handles all rainwater and chemical spills.	Design criteria
3. A holding and neutralization pond is used to increase pH to approximately 6 - 7 by the use of lime additions to neutralize normally acidic chemical waste materials.	Design criteria, procedure
4. Process areas built on proper grade to direct any spills to sewer system.	Design criteria
5. Process areas and other areas where strong acids are used are surrounded by curbing to direct the flow of any spilled liquids to the sewer system.	Design criteria
6. Process areas handling the most hazardous materials from a pollution viewpoint are completely surrounded by dikes drainage ditches, etc. and are provided with specific waste treatment facilities designed specifically for those materials being handled.	Design criteria, equipment

Principal Hazardous Materials: Acids, Inorganics.

PLANT S (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage	Requires proper dike drainage system operation to insure impounding of spills, and the proper transfer of waste disposal of the contained spill	Dikes are required by fire regulations, but also serve as an effective "fail-safe" spill prevention measure.
Process, others	Appropriate impounding and waste disposal treatment facilities required	
Process, other	Continuous pH measurement by submerged electrodes, with periodic check and calibration of instrumentation by plant personnel used	
Process	Adequate sewer system to convey spills to waste treatment facilities required	
Process, other	Appropriate sewer system to convey spills to waste treatment facilities required	
Process	The main waste treatment facilities of the plant provide backup for the specialized waste treatment facilities serving the hazardous process area	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN CHEMICAL FACILITY - PLANT T

ITEMS	TYPE
1. All of the processing units are located on concrete surface areas.	Design criteria
2. All concrete surface areas under processing units are constructed with a sloping grade toward drainage ditches.	Design criteria
3. Concrete lined ditches surround the concrete surfaced areas on which all processing units are located.	Design criteria
4. All piping above ground on overhead pipe racks.	Design criteria
5. The plant affluent stream is continuously monitored for BOD and TOD.	Design criteria, equipment
6. The activated sludge plant is equipped with a continuous TOD analyzer and recorder and alarm system.	Design criteria, equipment
7. The first one-half inch of rainfall goes through the neutralizing and treating ponds, while the remainder of each rainfall is discharged directly into the nearby watercourse.	Design criteria
8. Flexible loading hoses are blown clean with nitrogen into the vessel being loaded after the filling operation has been completed.	Procedure

PLANT T (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process		Prevents penetration of any spilled liquids into the soil.
Process		Spills are controlled by being directed away from their source toward the disposal facilities provided.
Process	Appropriate sewer system to remove spills required.	
Process, transfer		Permits visual detection of leaks or spills associated with transfer pipelines.
Waste treatment, other	This is a backup system for the main waste treatment facilities.	
Waste treatment	This is a backup system for the main waste treatment facilities.	
Process, other		The potentially dirty initial rainwater runoff is treated while the typically clean rainwater runoff from the latter part of each storm is diverted directly into the watercourse.
Loading and unloading		This procedure minimizes the liquid to be drained and collected from the loading hose after each loading operation has been completed.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN CHEMICAL FACILITY - PLANT T (Continued)

ITEMS	TYPE
9. When not used, loading hoses are capped to prevent drips.	Procedure
10. Tank cars and trucks are filled entirely by manual operations.	Procedure
11. The product tanks from which liquids are moved to the terminal location are mounted on load-cells which continuously weigh the total tank plus contents.	Design criteria, equipment
12. Specific storage tanks are surrounded by concrete fire walls (dikes)	Design criteria

Principal Hazardous Materials: Isocyanates, Amimes Caustic, Inorganic Acids.

PLANT T (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Loading and unloading		
Loading and unloading	Requires continuous operator attention	
Storage, loading and unloading	Data transmission and operator action required	This provides a direct and continuous monitoring of the total liquids moved from the storage tanks to the rail cars or tank trucks. It is don primarily for safety reasons, and because of the very high value of the products moved at this plant. However, this system also provides a means for quickly determining spills of liquids associated with the storage facilities.
Storage	Appropriate fire wall drainage and sewer systems required.	Dikes surround only the tanks containing flammable liquids. as dictated by fire regulation however, these dikes also serv as an effective "fail-safe" spill prevention measure.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN THE PETROCHEMICAL, CHEMICAL AND PLASTICS FACILITY -

PLANT U

ITEMS	TYPE
1. Most of the production units are located on concrete pads.	Design criteria
2. Concrete pad areas are built on a grade to direct chemical spills.	Design criteria
3. Curbing and/or ditches surround process unit concrete pad areas.	Design criteria
4. Many production units are equipped with a separate chemical sewer system.	Design criteria
5. All other process concrete pad areas are serviced by a single sewer system.	Design criteria
6. Certain production units are equipped with unit oil separators and/or other waste treatment facilities.	Design criteria, equipment
7. All of the loading and unloading terminal facilities which service carriers other than barges or vessels are built over concrete surfaced areas.	Design criteria
8. Concrete surfaced loading and unloading areas are graded toward drains connecting with the general sewer system.	Design criteria

PLANT U (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process	Suitable means for directing spills of liquids to collection and disposal facilities required	Insures that chemical spills are simply not absorbed into the soil.
Process	Suitable collection and handling means required	
Process	Suitable sewer system required	
Process	Suitable waste disposal facilities required	This is provided for the production units which handle or produce water soluble organic materials.
Process	A suitable single waste water treatment facility required	Processing areas which produce organic chemical liquids which are not soluble in water are serviced by the same sewer system which handles rainwater runnoff.
Process	Main waste treatment facilities required	This not only reduces the total load on the central waste treatment facilities serving this plant. but also permit more specific tailoring of the kind of waste treatment facilities used for each new unit.
Loading and unloading	Suitable sewer system required	
Loading and unloading	Suitable waste disposal facilities required	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN THE PETROCHEMICAL, CHEMICAL AND PLASTICS FACILITY -

PLANT U (Continued)

ITEMS	TYPE
9. Rail car and tank truck washing facilities are built on concrete surfaced areas which are connected to a unit oil separator and then to the sewer system.	Design criteria
10. The first one-half inch to one inch of rainfall over the entire plant area which is served by storm sewers drains into and is held by a large holding lagoon.	Design criteria
11. Suction trucks are used to remove waste sludge from the bottom of storage tanks.	Procedure, equipment
12. Vacuum trucks are used for removing large spills which are confined in specific areas such as behind dikes or curbing.	Procedure, equipment
13. A continuous TOD monitoring system is being developed.	Equipment. design criteria
14. Gas chromotography is being used to identify specific organic compounds contained in the waste water system.	Procedure

Plant U (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Loading and unloading	Suitable waste disposal facilities required.	
Waste treatment	This is a backup system for the main waste treatment facilities to even out the load imposed on it by rainstorms.	After the first one-half inch to one inch of rainfall, it has been found that the entire plant area will have been cleaned of chemical and oil spills. After this quantity of rainfall has run off and has been collected by the large storage lagoon, the remainder of the rainfall is discharged directly to the watercourse since it is essentially clean. After the rain has stopped, the oily water stored in the large lagoon can be slowly fed into the water treatment system.
Storage	The remainder of the sludge is washed from the bottom of the tank with water and drained to the sewer system.	
Storage other	Specific waste disposal facilities required.	The use of vacuum trucks for such purposes is increasing.
Process, waste treatment, others		
Waste treatment, others.	This is a backup system for processing operations.	The presence of any organic products in excess of the acceptable limits set by the company is traced to the specific operator responsible. This is perhaps the essence of spill prevention.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN THE PETROCHEMICAL, CHEMICAL AND PLASTICS FACILITY -

PLANT U (Continued)

ITEMS	TYPE
15. Continuous chromatographic analyzers are placed on the waste streams coming from specific production units.	Equipment, Design criteria

Principal Hazardous Materials: Polymers, Wide Range of Organics.

PLANT U (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Process, other	Appropriate operator action, required.	This decreases the lag time between a spill of specific products, reactants, or intermediates at their source, and the detection of these chemica This approach to spill detection is highly favored, and is increasing in its use.

ITEMS	TYPE
1. All of the process units are built on concrete pads.	Design criteria
2. All storage tanks are diked.	Design criteria
3 The first inch of rain which runs off the entire plant area goes to a storm water holding pond.	Design criteria
5 Separate chemical sewer and clean water storm sewer drainage systems.	Design criteria
6. A separate chemical sewer takes spills from specially curbed areas such as around pumps and certain process units which produce either a continuous discharge or have a high risk of chemical spills.	Design criteria
7. All storage tanks are surrounded by dikes.	Design criteria
8. The rail car loading area is graded to drain to a concrete lined trough paralleling the rail tracks and located on each side of the tracks.	Design criteria
9 The troughs which handle spills at the rail car loading and unloading facilities empty into a special catchment basin with a capacity equivalent to one inch of rainfall on the entire track loading terminal area	Design criteria

PLANT V (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEM	REMARKS
Process	Suitable means for collecting and treating waste chemical spills required.	
Storage, other		
Process, other	Suitable waste treatment facilities required.	After the first inch of rain runs off the plant area, it is clean, thereby permitting the remaining rainwater to run off directly to the nearby watercourse.
Process, other		Insures chemical spills do not get into the rainwater discharge from the facilities.
Process, other	Suitable waste disposal facilities used.	
Storage, other	[illegible] proper dike drainage system operation to insure impounding of spills, and the proper transfer to waste disposal of the contained spill.	Dikes are required by fire regulations, but also serve as an effective "fail-safe" spill prevention measure.
Loading and unloading	Suitable sewer system to handle spills required.	
Loading and unloading	Suitable waste disposal facilities required.	

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN CHEMICAL AND PETROCHEMICAL FACILITY

PLANT V (Continued)

ITEMS	TYPE	AREA
10. The entire marine terminal dock is constructed of concrete, is curbed, and has its surface sloped toward stainless steel drains.	Design criteria	Loading and unloading
11. At the conclusion of loading operations, the onshore valve is closed, and the hose between the valve and the barge is blown out using pressurized nitrogen.	Design criteria, procedure	Loading and unloading
12. Remote shutdown for loading transfer pumps.	Design criteria, equipment	Loading and unloading

Principal Hazardous Materials: Ethylene, Acetic Acid, Cyclohexane, Organics.

PLANT V (Continued)

REQUIRED OR USED BACK-UP SYSTEM	REMARKS
Stainless steel waste storage tank located below dock area used.	
This is a backup system for the directly controlled loading operation under the supervision of a registered tanker man.	This remote control for the loading pump is a safety requirement, but also functions as an environmental protection feature.

DESIGN CRITERIA, PROCEDURES AND EQUIPMENT IN CHEMICAL FACILITY - PLANT W

ITEMS	TYPE
1. Some storage tanks are diked.	Design criteria
2. Regular periodic inspection using standard procedures for all piping including hydrostatic testing and visual inspection.	Procedure

Principal Hazardous Materials: Inorganic Solids

PLANT W (Continued)

AREA	REQUIRED OR USED BACK-UP SYSTEMS	REMARKS
Storage	Suitable means for transporting and handling waste chemical spills required.	Dikes are required by fire regulations, and therefore surround tanks containing flammable materials only; dikes however also serve as an effective "fail-safe" spill prevention measure.
Transfer, other		Primary purpose is to prevent accidents--built-in spill prevention and detection aspects.

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED BY ARCHITECT-ENGINEERING FIRMS

	ITEM	TYPE	AREA	BACK-UP SYSTEMS
1.	Location by area function, i.e., process, storage, loading utility, etc.	Design Criteria	all	not applicable
2.	Dual Sewers in loading & unloading area one for spills, one for rain runoff	Design Criteria	Loading & Unloading	Curbed area & hard surfacing
3.	Hard surfacing of loading and unloading area	Design Criteria	Loading & Unloading	Curbs and separate sewers
4.	Curbing	Design Criteria		
	(a) Process		Process	Sloping surface to appropriate sewer
	(b) Loading		Loading	
	(c) Unloading		Unloading	
	(d) Transfer		Transfer	" "
5.	Gravel or shell covering of loading	Design Criteria	Loading & Unloading	Grade to sewer
6.	Flame Arrestors in Sewer Systems	Design Criteria	all	
7.	Loading arms and "dead man" controls	Design Criteria, Equipment	Loading	Hard surfaced, sewered areas
8.	Drip pans under selected joints, etc., in loading and unloading area	Design Criteria Equipment	Loading & Unloading	Plant Collection system
9.	Dikes around storage tanks	Design Criteria,	Storage	Fail-safe valve system in diked area for drainage
	(a) Flammable Liquids		"	
	(b) Non-Flammable Liquids		"	
10.	Process Wastewater Treatment Plant	Design Criteria.	all	Catchment basins or holding lagoons
11.	Holding Lagoon	Design Criteria	all	Diversionary Sewers, etc.

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED BY ARCHITECT-ENGINEERING FIRMS

(Continued)

	Company Recommended or Industry Standard					If Required by Client				
REMARKS	Companies					Companies				
	AA	AB	AC	AD	AE	AA	AB	AC	AD	AE
Systematizes Designs and Spill Control Problem	X	X	X	X	X					
Permits special handling of most hazardous concentrations	X	X	X	X						X
Permits special handling of most hazardous concentrations	X	X	X	X						X
Controlling spread of liquids	X	X	X	X	X					
" " "	X	X	X	X	X					
" " "	X	X	X	X	X					
" " "	X	X	X	X	X					
Essentially for personnel convenience. Requires all rainwater treatment						X				
To prevent spread of flames via sewer system	X	X	X	X	X					
Reduce dependency on operator attention	X		X				X		X	X
Low cost, selective control system						X	X	X	X	X
Passive Barrier, Primary Defense	X	X	X	X	X	X	X	X	X	X
Permits removal of spilled materials on controlled basis	X	X	X	X	X					
Permits segregation for controlled treatment or release	X	X	X	X	X					

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED BY ARCHITECT-ENGINEERING FIRMS (continued)

	ITEM	TYPE	AREA	BACK-UP SYSTEMS
12.	Selective Segregation of Storm Water	Design Criteria, Procedure	all	Diversinary mechanism
13.	Separate Process sewers from process area drainage	Design Criteria, Procedure	Process	Wastewater Treatment plant & holding lagoon
14.	High&low liquid level alarms on storage & process tanks	Design Criteria	Process & Storage	Monitors and alarms
15.	Above ground piping on racks	Design Criteria	Process Transfer	Drainage collection under rack
16.	Fixed Boom loading arms instead of hoses on marine facilities	Design	Transfer	Curbed areas
17.	Tank Hydrostatic Testing Program	Procedure	Storage, Process	
18.	Manual Pump out connections for tank emptying	Design Criteria, Procedure	Storage	Spare Tankage
19.	Automatic Controls on pH at wastewater treatment plant	Design Criteria, Equipment	Waste Treatment	
20.	Liquid knockout drums on gas relief system	Design Criteria, Equipment	Process	Process Drainage
21.	Installation of fin-fan coolers	Design, Criteria	Process	
22.	Detection Instrumentation in wastewater lines-especially oil	Design, Criteria Equipment	Process	
23.	All welded transfer piping systems	Design Criteria	Process Transfer	

DESIGN CRITERIA, EQUIPMENT AND PROCEDURES USED BY ARCHITECT-ENGINEERING FIRMS

(Continued)

REMARKS	Company Recommended or Industry Standard					If Required by Client				
	Companies					Companies				
	AA	AB	AC	AD	AE	AA	AB	AC	AD	AE
Permits holdup of initial storm runoff for subsequent treatment	X	X	X	X						X
Permits most effective treatments	X		X	X			X			X
Active detection	X		X				X			
Prevents uncontrolled spread of liquids from pipe breaks	X			X			X	X		X
Pipelines should be periodically tested		X		X						
Recommendation to client--no responsibility for program		X								
Removal to permit repairs			X			X	X		X	X
Rapid response to control			X			X	X			X
Prevents liquids from being blown onto uncontrolled areas			X							
Replace water cooling system			X			X	X		X	
Active alarm				X		X	X	X		X
Reduces potential of leaks from flanges	X	X	X	X	X					

APPENDIX G

TYPICAL PROCEDURE (JOB STANDARD) FOR TRANSFER OPERATION IN CHEMICAL INDUSTRY

TYPICAL OPERATING STANDARD AND CHECK LIST FOR LOADING AND DISCHARGING OF SHIPS

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JOB STANDARD

Plant Sym. No. Rev: L 400 PJ 1542

OPERATION PRODUCT and LOCATION: PUMP STOCK FROM SCALE TANK TO W. FIELD STORAGE, WEST FIELD & BLDG. #2

PAGE 1 OF 3

MACHINE and EQUIPMENT DATA TOOLS: PIPING, VALVES, PUMP, AIR SYSTEM, FLOW DRUM, JAR, TAG

SUPERSEDES: Pd 1540 AGE

REASON FOR SUPERSEDURE: COMPLETE REVISION

PARTICIPANTS No. 1

WORK PRODUCED SHOULD BE VERIFIED BY

Operation Studied: PUMPER

S M M Q CHART

REPORT: PUMPING

Form No.: 7 - 221

ACTUAL OBSERVATION

No.	C	NORMAL FREQUENCY 3/[illegible] — ELEMENTS IN FULL DETAIL Work Elements Must Be Performed As Described Below	REF FILE No	Occ Per PUMPING	STD HRS
		SUMMARY:			
		A. PUMP STOCK FROM SCALE TANK #120 TO WEST FIELD TANK WHEN NO SAMPLE IS NEEDED (Els. 1-7, 9, 11-13, 15, 18, 20-22)		Pumping	.5732
		B. ADDITIONAL ALLOWANCE FOR TAKING FLOW DRUM SAMPLE REQUIRED APPROXIMATELY 9/10 PUMPINGS (Els. 8,10,14,16,17,19)		Sample	.0622
		C. TOTAL ALLOWANCE TO PUMP STOCK FROM SCALE TANK #120 TO WEST FIELD TANK WHEN FLOW DRUM SAMPLE IS REQUIRED (Els. 1-22)		Pumping	.6354
1		CHECK SCALE WEIGHT & RECORD Walk to scale tank (13' avg.)(.0012). Set scales and check weight of stock in tank (.0014). Record in pocket notebook (.0024).		1	.0050
2	O	PUT AIR ON LINE Line is set with air to be sure that line is set to correct tank. Walk to air valves group at tank (33' avg.)(.0024). Close bleeder and open two 3/4" valves to turn on air (.0042). Return to front of scale tank (33' avg.)(.0024).		1	.0090
3		SET LINE IN BSMT. Pull chain extensions to open one 2½" valve and close one 2½" valve above main aisle (.0030). Go to area near pump, pull chain extensions to open one 2½" valve and close 2½" valve (.0093). Go to S&S mezzanine level (55' avg. + 21 su)(.0087). Check 2 - 3" valves and open or close one 3" valve (.0059). Step to E. side of mezzanine (5'). Check an avg. of one 4" valve. Open or close 3 - 4" valves (.0154). Walk to areaway south of S&S bsmt. (90' + 21 sd + 4 su)(.0097). Open and close an avg. of 4 - 4" valves to set line (.0165).		1	.0745
4		SET LINE TO FIELD TANK. CHECK AIR THROUGH Walk from valves near S&S basement door to valve group at end (west) of areaway by storeroom (216')(.0126). Open one 4" valve. Close one 4" valve (.0110). Walk to valve group outside west pump house (193' + 14 su). **Observe 3 valves on line to be sure they are set properly (.0144). Open one 4" valve, close 2-4" valves (.0165). Step to west tank farm (57' + 3 su). Open and** close an avg. of 8 valves to set line to tank. Walk an avg. of 154' + 2 sd while setting line (.0775). Close one 4" valve **on line. Open riser valve on tank slowly to feel rush of air into tank (.0072).**		1	.1392

FREQUENCY of AUDIT: 1/yr. min.

STUDIED BY: S.T.Millard

CHANGES BY

TOTAL STD HRS PER: SEE SUMMARY ------

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2. Plant
3. I. E. Div.
4. Dept. Mgr.
5. Group Mgr.

Req By Dept. Mgr.

App By Group Mgr.

OK's

App By Ind Engr

EFFECTIVE DATE

Authorized By

Plant Mgr.

Date	Auditor	O.E.	Bef O.E.	Date	Auditor	O.E.	Bef O.E.

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JOB STANDARD

L 400 Pd 1540 Plant Sym. No. Rev.

OPERATION PRODUCT and LOCATION: PUMP STOCK FROM SCALE TK. TO W. FIELD STORAGE, W. FIELD & BLDG. #26

PAGE 2 OF 3

No.	C	ELEMENTS IN FULL DETAIL Work Elements Must Be Performed As Described Below	Occ. Per	STD HRS
5		GAUGE TANK, RECORD IN PNB Go to gauge board on tank (15' avg.). Pull gauge chain, read gauge (.0039). Record starting gauge in pocket notebook (.0024).	1	.0063
6		RETURN TO S&S BSMT., TURN OFF AIR Return to S&S basement (643' + 21 sd + od)(.0436). Close two 3/4" valves to shut off air, open bleeder (.0042). Walk to flow drum or scale tank (15')(.0013).	1	.0491
7		START PUMPING, BLEED PUMP Open 4' extension handle bottom valve to scale tank (.0055). Step to pump switch (33')(.0024). Push button to start pump (.0006). Open bleeder valve at pump to bleed air and close bleeder when oil appears (.0033).	1	.0118
8	O	REGULATE OIL INTO FLOW DRUM It is important that flow to flow drum be so regulated that no further adjustment be made during pumping. This is to insure an equal flow during pumping so that an accurate sample is obtained. Open 1" valve in line to flow drum (.0014). Walk to flow drum (15' avg.). Step up to flow drum. Inspect and adjust flow into flow drum. Step down from drum (.0049).	1	.0063
9		CHECK OIL INTO RECEIVING TANK **Walk to storage tank in W. tank farm to which oil is being pumped (688' + 21 su + 2 sd + od)(.0427). Note flow of oil into tank by placing ear against riser pipe line (.0010). Return to S&S bsmt. (674' + 21 su + 2 su + od)(.0468)**	1	.0905
10		PREPARE SAMPLE TAG, JAR AND FILL IN SAMPLE BOOK When at operator's desk, get sample tag from drawer in desk. Fill in nec. information on sample tag (.0070). Get sample book from desk and pencil from pocket. Fill out the necessary information in the sample book relative to no., code, stock, etc. (.0056). Walk from other work in area to sample jar storage at tank 110 (5'). Get liner, place liner in cap and screw cap on clean sample jar (.0032). Step to scale beam (10' avg.). Set sample jar on tank scale beam (.0008).	1	.0166
11		CHECK PROGRESS OF PUMPING DURING OTHER WORK (.0029) Walk from other work to scale (10' avg.). Balance scale for approx. weight to note progress of pumping (40,000# avg. pumping).	4	.0116
12		ATTENTION TO LAST OF PUMPING Walk from other work to scale (10' avg.). Watch and move scale beam while pumping last of stock from scale tank.	1	.0300
13		STOP PUMPING AND BLOW LINE Walk to rear of scale tank (35' avg.)(.0025). Close valve in line under tank (.0055). Open two 1" valves, close bleeder to air blow line from scale tank to west farm tank (.0053).	1	.0133
14	O	TURN ON AGITATOR IN FLOW DRUM Oil in flow drum must agitate for at least 2-3 minutes before taking sample. This is done to insure well mixed sample. Step to flow drum (12' + 2 su avg.). Open 1" valve to turn on air to contents of flow drum (.0029).	1	.0029

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JOB STANDARD

L 400 Pd 1540 Plant Sym. No. Rev

OPERATION PRODUCT and LOCATION: PUMP STOCK FROM SCALE TK. TO W. FIELD STORAGE, W. FIELD & BLDG. 825

PAGE 3 OF 3

No.	C	ELEMENTS IN FULL DETAIL Work Elements Must Be Performed As Described Below	Occ. Per	STD HRS
15		TURN OFF PUMP Walk to pump switch (16' avg.), push button to stop pump(.0020). Walk to other work (30'), while flow drum agitates (.0022).	1	.0042
16		TAKE SAMPLE, TURN OFF AGITATION Walk to scale tank (11'), get sample bottle, walk to flow drum (25' + 2 su)(.0035). Remove cap and place in pocket, use dipper to dip sample from flow drum to sample bottle or jar, cap bottle (.0062). Close ½" valve to turn off air (.0014).	1	.0111
17		PUMP OIL FROM FLOW DRUM Open 2" bottom valve to flow drum (.0028). Walk (4' avg.), push button starting pump (.0012). Return and check pumping from flow drum (.0100). Step down and close 2" bottom valve of flow drum (.0034).	1	.0174
18		TURN ON AIR TO BLOW STOCK & SAMPLE LINE Walk to air valves (25' avg.), close bleeder and open two valves to turn on air to blow line (.0053). Walk to pump (34' avg.), set sample (if any) aside on scale of tank (.0024). Open bleeder, check air through pump, close bleeder (.0036).	1	.0113
19		STOP PUMP. CLEAR SAMPLE LINE Push button to stop pump (.0006). Open ½" flow line valve. Close 2-½" valve in line from pump so as to force air through sample line to flow drum. Blow line. Open 2½" valve. Close ½" valve (.0073).	1	.0079
20	O	STOP LINE BLOW Line to W. field must be blown for at least 20 minutes to clear line. Walk to air valves (30' avg.)(.0022). Close 2 air valves, open bleeder (.0042).	1	.0064
21		TAKE FINISH GAUGE ON W.F. TANK. CLOSE RISER Walk to tank in west field (683' + 21 su + 2 sd + od)(.0517). Gauge tank and record in pad (.0039). Close 4" riser valve on tank (.0035). Return to scale tank in bsmt. (683' + 21 sd + 2 su + od)(.0314).	1	.0925
22		RECORD FINAL WEIGHT Set scales and check final weight (.0042). Subtract final weight from starting weight to calculate net weight pumped (.0040). Make necessary entries on pump sheet. Show tank nos., amount pumped, etc. (.0093).	1	.0175

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STANDARD OIL COMPANY OF CALIFORNIA
WESTERN OPERATIONS, INC.
RICHMOND, CALIFORNIA

VESSEL'S NAME______________________________ DATE______________________________

Our Operating Standard RE-3110 "Loading and Discharging Ships at Manufacturing Department Terminals" describes the rules and regulations governing the operation of this Wharf. A complete copy is available for you to read upon request. The following is an abstract of these rules and regulations:

1. "Class A" products include all oils under 115°F closed cup flash or all oils handled at or above their closed cup flash temperature or all oils loaded into a tank containing Class A products and not subsequently gas freed.
2. "Class B" products include all oils of 115°F and higher closed cup flash when handled at temperatures below their flash temperature.
3. No smoking on the Wharf or in the Berth Offices.
4. No smoking on the weather decks of your Ship. Smoking permitted aboard ship only in locations designated by the Master. Portholes on the Wharf side shall be kept closed or screened while ship is along side Wharf. Doors and portholes facing loading decks shall be kept closed except for momentary passage.
5. In case of fire, stop cargo movements and handle oil lines as directed by Wharf. Ship's fire fighting equipment must remain operative while at Wharf.
6. Potential sources of ignition, particularly small power craft, should not be allowed to approach your Ship nearer than 100 feet.
7. Ship's Officer and Wharf Representative shall agree upon the method of communicating during cargo movements. Cargo movements shall not begin until the vessel and the Wharf inform each other that lines, valves and tanks are properly set.
8. Vessel is responsible for proper make-up of ship's hose connection, adequate hose support. Avoid hose kinks. Maintain hose bends above 12 diameters.
9. Tank tops must be kept closed at all times. Ullage plugs are to be kept closed at all times except when sampling, thieving or inspecting, at which time they can be opened for the necessary time and then immediately closed. Tank tops may be open if gas free.

*10. No ballasting during cargo movements except when ballast handling is in a separate system from bulk cargo handling. Ballast discharge over side prohibited. Use shore tank only.

11. Proper preparation of tanks is Ship's responsibility. Consultation is available.
12. Vessel is responsible for all on board cargo movements.
13. Start loading slowly and by gravity when possible. Top off tank by gravity when possible.
14. Vessel shall report Ship's tank gages every 2 hours.
15. Class A products shall not be displaced from cargo hoses with compressed air.
16. Scupper plugs shall be tightly fitted on the weather deck in way of tanks before cargo or bunker movement can start.
17. Hose limits: 150°F, 125 psig.
18. If contamination or a serious leak is discovered, discontinue the stock movement until agreement is reached on the proper procedure to follow.
19. Your ship must be able to get underway while at Wharf. Bitter end of mooring lines must not be secured. Fire wires must be out at bow and stern.
20. No other vessel is permitted to moor alongside or allow cargo movements across the decks of a Class A vessel.
21. Boiler fires shall be adjusted so as to prevent "Stack Burnouts".
22. Wireless transmission is prohibited. Electrical repair work is prohibited.
23. Handling of all ship stores will be the responsibility of the ship's Officer.
24. Abide by Federal, State and Local Air and Water Pollution Laws.
25. Vessel shall provide own gangway. Wharf gangway normally is not available.

*Revised 3-31-70

26. You must provide your own doctor or ambulance service. A local list can be obtained from the Wharfmaster.
27. Keep both anchors housed.
28. Special situations, such as repair work, require Terminal Executive approval.
29. Pedestrians are not permitted on Long Wharf causeway. Ride the Company-provided bus.
30. Paying passengers cannot board and must stay aboard your vessel.
31. So that shore booster pumps and manifolds can be properly adjusted to eliminate possible hazards to these facilities, a 15-minute notification shall be given to the wharf men in charge of the berth prior to the:
    (1) Stopping of any cargo movement.
    (2) Stripping of any tanks during cargo discharge.
32. Cover ship's sewer outlet to deflect material into the water instead of on the deck.
*33. Cleaning of ship's tanks and/or butterworthing alongside wharves is prohibited.
*34. Deck-watch required at all times while loading/discharging.

I will abide by the rules and regulations as set forth in Operating Standard RE-3110, "Loading and Discharging Ships at Manufacturing Terminals", as well as those prescribed by Law.

SIGNED____________________
(BERTH OPERATOR)

SIGNED____________________
(MASTER OR AUTHORIZED REPRESENTATIVE)

____
(NAME OF VESSEL)

____
(DATE) (TIME)

- -

The following section of this form should be used for special situations:

____________ (NAME OF VESSEL) ____________ (DATE) ____________ (TIME)

Wharf approval is required before ship can steam, wash or gas free tanks.

____
(TERMINAL EXECUTIVE OR AUTHORIZED REPRESENTATIV

The freight holds and/or tanks of this vessel have been inspected/tested and have been found safe for men to enter and/or work. (Must be signed before Company personnel can enter a freight hold or ship's tank.)

____
(MASTER OR AUTHORIZED REPRESENTATIVE)

Special situations should be listed here.

____________________ ____________

____________________ ____________

*Revised 3-31-70

STANDARD OIL COMPANY OF CALIFORNIA
LONG WHARF/POINT ORIENT WHARF
RICHMOND, CALIFORNIA

VESSEL: ____________________
BERTH: ____________________
DATE: ____________________

Check list of items to be discussed between the Captain, Chief Mate, Chief Engineer and Wharfmaster before start of cargo operation. Oil transfer may not start until all questions have been checked off in the "Yes" circle and attested below. Each oncoming Wharfmaster and Mate must sign.

1. Written cargo and bunker orders have been reviewed and agreed upon as to:

	Yes
a. Quantity & Type of Stock	( )
b. Initial Transfer Rate	( )
c. Maximum Transfer Rate	( )
d. Maximum Line Pressure	( )
e. Maximum Temperature	( )
f. Anticipated Stoppages	( )
g. Booster Pumps	( )

2. The method of communication (signaling practice) between ship and shore has been established. ( )

3. It is understood a 15 minute standby notice to both ship and shore is required for shutting down any cargo transfer, except in an emergency. ( )

4. Do all agree vessel and gangway is properly secured at Wharf? ( )

5. All bolted connections between ship and shore are full bolted. ( )

6. If a hold-out (displacement) is required, has the amount and procedure been agreed upon? ( )

7. Is there a clear understanding at the terminal and on board ship the steps to be taken for containment and clean-up in the event of an oil spill? ( )

8. Are cargo/bunker hoses in good condition? ( )

9. Sea suction valves will be properly lashed and opened only if under the direct supervision of the Officer in charge. Wharfmaster to be notified when valves opened. ( )

10. Has any anticipated repair work been brought to the Wharfmaster's attention? ( )

11. Ship and shore 2-hour gages will be exchanged. ( )

12. Portholes on Wharf side are closed or properly screened. ( )

	WHARFMASTER		SHIP'S OFFICER	TITLE		SHIP'S OFFICER	TITLE
1.		1.			7.		
2.		2.			8.		
3.		3.			9.		
4.		4.			10.		
5.		5.			11.		
6.		6.			12.		

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